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Theory, the Greatest Tool of Reasoning

Few things are more disconcerting to most of us than to be suddenly asked to define some common word. You think you know the difference between "plant" and "animal," but try to write a definition of either one of these class terms that will pass uncriticized by a biologist.

The writer was once asked on the witness stand whether a theory is as trustworthy as a fact. He replied by asking the lawyer to define the word theory. The attorney started to do so, but was quick enough to see that he would probably make a mess of it, so he countered by saying that he was not under cross-examination himself, and that the witness could give his own definition of theory.

In his Logic, Mill distinguishes between an hypothesis and a theory. An hypothesis may be called a provisional theory, and a theory may be called an established hypothesis, according to Mill. A scientific theory is an explanation of a phenomenon. Usually the explanation consists in giving the causes of a given effect. Spencer says that we explain a previously unknown thing when we are able to show that it belongs to a known class of things; thus if a rustle is heard in the grass, we may be unable to explain it until some other sound or sight enables us to classify the cause of it. Perhaps the chirp of a bird or the sight of a bird in the place whence the rustling sound came serves to enable us to explain the rustle.

La Place formulated his celebrated "nebular hypothesis" to explain the origin of the solar universe. Several facts were explained by this hypothesis, notably the fact that all the planets revolve in the same direction around the sun, and that this direction is the same as the one in which the sun rotates about its own axis. Yet certain other facts remain unexplained by this hypothesis, notably that the moons of certain planets revolve in a retrograde or opposite direction; and that the planets have a periodic arrangement. So the nebular hypothesis has continued to be called an hypothesis and not a theory. In popular parlance, however, no distinction is made between hypothesis and theory, any explanation, however farfetched, being called a theory.

If a theory is nothing but an explanation, why do we so commonly hear disparaging remarks about theories and theorists? The answer seems to be that those who speak slightingly of theories have never stopped to define the word. Someone has pointed out that the "practical men" who are prone to decry theories are themselves stuffed with theories. Ask any practical man why so and so occurs, and he will almost invariably essay an answer; that is, he will offer his theory. Probably it will be a lamentably crude explanation, often impromptu in its conception, generally unsupported by more than one or two facts, yet it will be uttered with every mark of assurance.

Let the same practical man hear a scientific theory expounded by one who has gathered and examined all the evidence after years of study and experiment, and what is the common reaction of that practical man? "Oh, it sounds very plausible, but of course it is merely a theory."

Well, it is merely a theory that the earth revolves about the sun, acting under a theoretical force called gravitation; and that the four seasons result; and it is merely a theory that day and night are the result of the earth's rotation about an axis that no man has ever seen. And it was mere theory that the earth is round that led Columbus to undertake his celebrated voyage in 1492. So mere theory may be a very practical thing.

When you fully grasp the meaning of the word theory you see that sound theory is the very basis of sound practice. A theory merely asserts that certain effects have been produced by certain causes. The germ theory of disease was one of the most benificent theories ever propounded. Prior to that there had been disease theories galore, ranging from the "devil theory" to the theory of "disease humors" that called for frequent blood lettings.

Sound theory, then, is itself a fact, for all it asserts is a sequence of events of a given class. Most theories are either wholly or partially unsound, and that explains why the word theory conveys to most minds a sense of uncertainty. But because most theories are unsound is no reason for being antagonistic toward all theories. If such an attitude were logical, we should remain dumb because so few of us use entirely correct language. Nearly all tools are defective in some particular. Shall we speak slightingly of all tools in consequence? It will be better to busy ourselves removing the defects, and improving our skill in the use of our tools.

Theory is man's greatest reasoning tool. Let us try to speak of it with more respect and less ridicule.

H. P. Gillette

A Couple Pages of Highway Kinks

Notes from the Field and Construction Manuals of State Highway Commissions

BITUMINOUS MATERIALS.—The following interesting note was taken from the Construction Manual of the State Road Commission of West Virginia:

Bituminous material must have continuous inspection during placing. The inspector will check the temperature of each tank car and each distributor load and will also figure the distance it should go, marking off the same. In figuring these distances, keep in mind that the rate per square yard called for is based on cold material. To get the volume in gallons at any temperature, t, (Fahrenheit) to give 1 gal. at cold temperature (60 degress Fahrenheit) use the formula,

Required volume $= 1 + K\ (t—60)$ where K=.00030.

A daily record must be kept of the approximate amount in each tank load of bituminous material, and the total distance of both first and second applications spread each day. Samples must be taken from each car of bituminous material and sent to the testing laboratory.

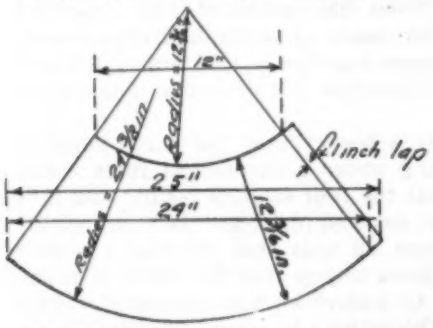
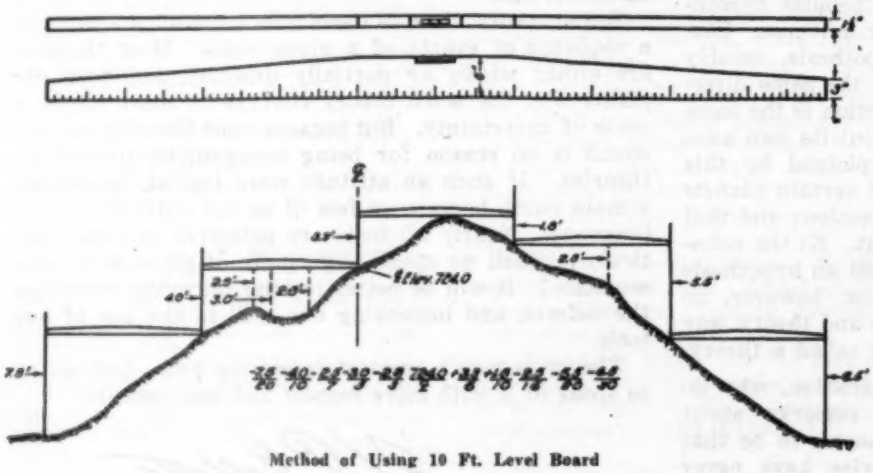


Diagram for Cutting Metal to Make Frustum of Cone Used for Slump Test.

Grade Compensation.—From the same source given above we note that the loss in traction due to curvature on a maximum grade of 7 per cent is negligible for curves of 10 degrees or flatter. Sharper curves, however, require grade compensation. The amount of this compensation should be 0.075 ft. for each degree greater than 10 degrees, based on a 7 per cent maximum grade. The full compensation should be carried for the entire length of the curve from the P. C. to the P. T. This compensated grade represents the maximum grade for these curves. This should be reduced if possible.

If future improvements demand the elimination of curves the grade should be flat to permit this change to be made, without abandoning any more of the road than absoutely necessary.



Method of Using 10 Ft. Level Board

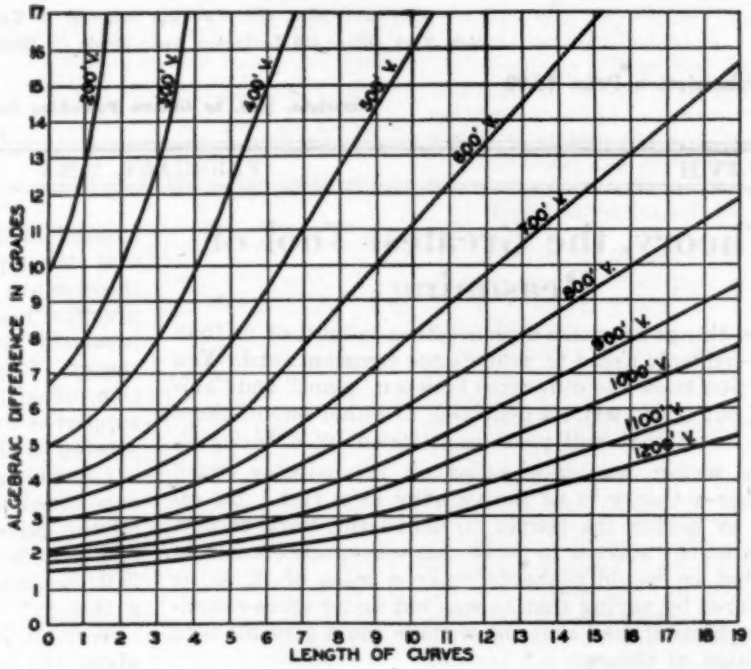


Diagram for Determining Length of Vertical Curve

Grade Compensation.—The Manual of Instructions of the California Department of Public Works shows a little different method but the fundamental idea is the same. It states that maximum ruling grades on location of 6 per cent and over shall be compensated on curves up to 1,000 ft. radius according to the following formula:

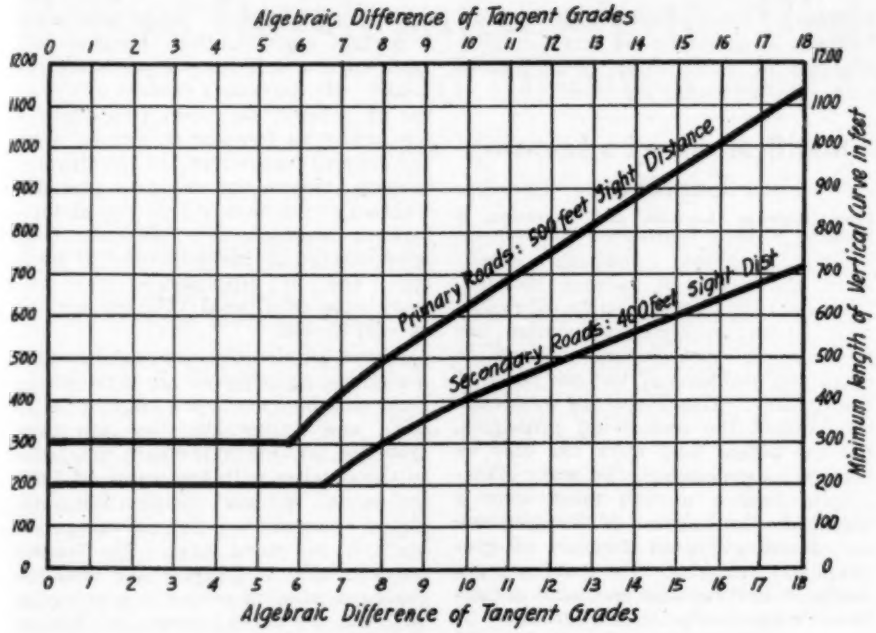
$$C\ (\text{in } \%) = \frac{125}{R}, \text{ where}$$

C equals the correction in per cent to be deducted from the ruling grade and

R equals Radius of Curve.

The compensation provided by the foregoing formula does not include or contemplate any compensation which may be necessary to furnish slack grade for future shortening of the line. Where improvement in alignment is anticipated separate and additional compensation must be introduced.

Branding Irons.—Michigan is a long jump from the cattle country. If the use of branding irons had occurred in some of the states from Texas to Montana we would not have thought so much about it. Regarding marking construction stakes the field manual of the Michigan State Highway Department states that branding irons are furnished each survey party for the purpose of branding the numbers on the stakes. High test gas should be used in the torches, especially



Read length of Vertical Curve to nearest 100 ft.
Minimum Length of Vertical Curves

during cold weather. If the iron is properly heated and the stakes laid out in rows with the points to the left hand of the operator the stakes will be numbered as fast as marking with keel. Care should be taken not to burn the numbers too deep. The stakes should then be tied in bundles of ten sets and distributed every 1,000 ft. Any stakes broken in driving should be noted and fresh stakes branded to take their place.

Level Board.—The most common error in taking cross sections according to the Construction Manual of the Ohio Department of Highways is in the number taken. Very few plans for projects in rough country show enough cross sections. Computing excavation from cross sections is, at best, only approximate; how near it will approach the actual quantities depends largely on the judgment of the engineer in the field.

The 10 ft. level board shown on page 72 will be found very useful on steep slopes where the use of a wye level would be impractical. It is more accurate than the hand level, generally takes less time and requires one less man on the party. The main objection is that any mistakes or errors are carried through for the balance of the section.

In taking notes all elevations are referred to center line elevation as a bench mark. At each 10 ft. interval from center line a temporary turning point is established. All readings in subsequent intervals are referred to the turning point immediately proceding.

How to Make a Slump Test Cone.—It sometimes happens that the slump test cone gets lost or damaged on the job. After a trip to the nearest sheet metal shop or tin shop with the accompanying diagram the cone can soon be replaced.

This can be cut from a sheet 15 in. wide and 26 in. long, not lighter than 20 gauge. The diagram on page 72 was taken from the Field Manual of the New Mexico State Highway Department which recommended the following:

Type of Concrete	Maximum Slumps In.
Mass Concrete	2
Reinforced Concrete.	
Thin Vertical Sections	6
Heavy Sections	2
Thin Confined Horizontal Sections	8
Roads and Pavements.	
Hand Finished	4
Machine Finished	1
Mortar for Floor Finish	2

Visibility Over Hills.—The several states use about as many methods of determining the lengths of vertical curves over hills. The accompanying diagram taken from the Construction Manual of the Ohio Department of Highways and Public Works is used as a guide to designers and field parties in that state.

The following example shows the use of the curves on page 72 for any desired sight distance:

Given: Plus 6 per cent grade and minus 6 per cent grade.

Algebraic difference=12.

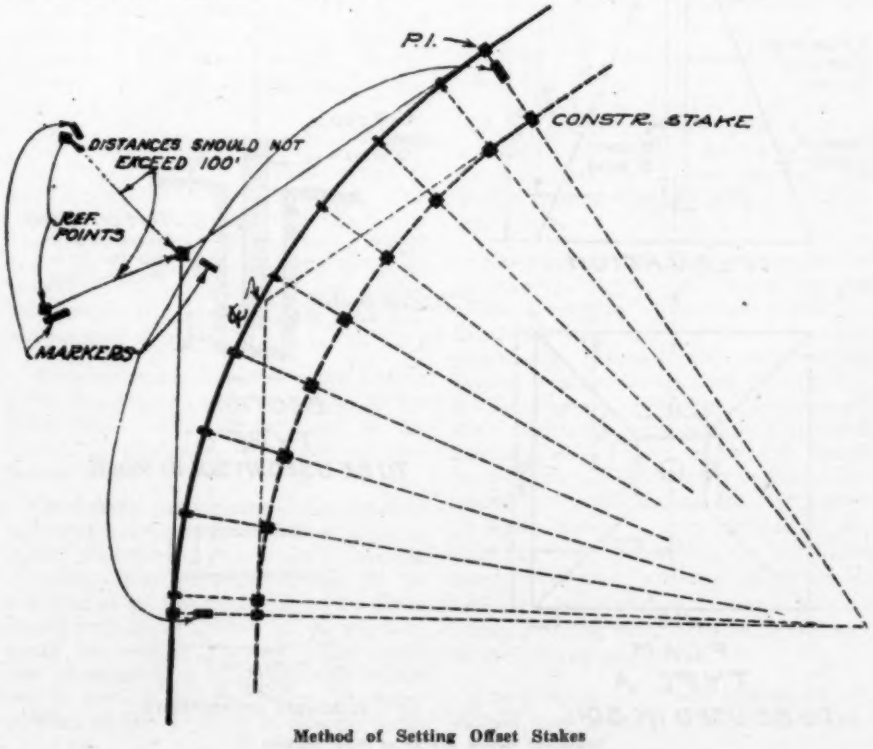
Enter vertical axis with 12 and intersect with curve. Drop down to horizontal axis and read 7.5. Therefore the length of vertical curve must be 750 ft. to give a clear vision of 500 ft.

Missouri, on the other hand, uses a 500 ft. standard for sight distance on their primary road system as shown by the field manual of the Missouri State Highway Commission from which the accompanying diagram was taken.

Staking Offset Lines.—On curves, the center line and construction stakes should be on true radial lines, which may be obtained either by setting the center on short radius curves, and sighting in by eye, or running curve on both center line and offset.

In practically all cases, it is possible to run on the offset line, both on tangents and curves, and this should be done, as construction stakes, and not center line stakes, control the final position of the completed road according to the Field Manual of the New Mexico State Highway Department.

Running curves on offset line is accomplished by using the same deflection angles as figured for center line,



Method of Setting Offset Stakes

with corrected chord length, in the proportion of center line radius to offset line radius.

Thus, in the case of 10° curve; offset line 40 ft. right.

Center Line Radius=573.0 ft.
Offset Line Radius=533.0 ft.
Proportion=573: 533:: 1: X.

$\frac{533}{573}$ =0.93=value of 1.0 ft. on center line, when corrected for offset line.

Tangent distances and chord lengths obtained by simple multiplication.

Bench Marks. — Considerable time and expense is involved in carrying bench levels to and along a construction project. Very often the project is so situated that there are no natural places available on which to leave a permanent reference elevation. In progressive highway construction methods it is essential to economy that these permanent bench marks be scattered along the project for future construction. Physical evidence of such marks is far superior to note book records. In recognition of this fact the Field Manual of the New Mexico State Highway Department gives three methods as shown in the accompanying diagram of establishing bench marks to fit the particular condition.

Qualifications of a Locating Engineer

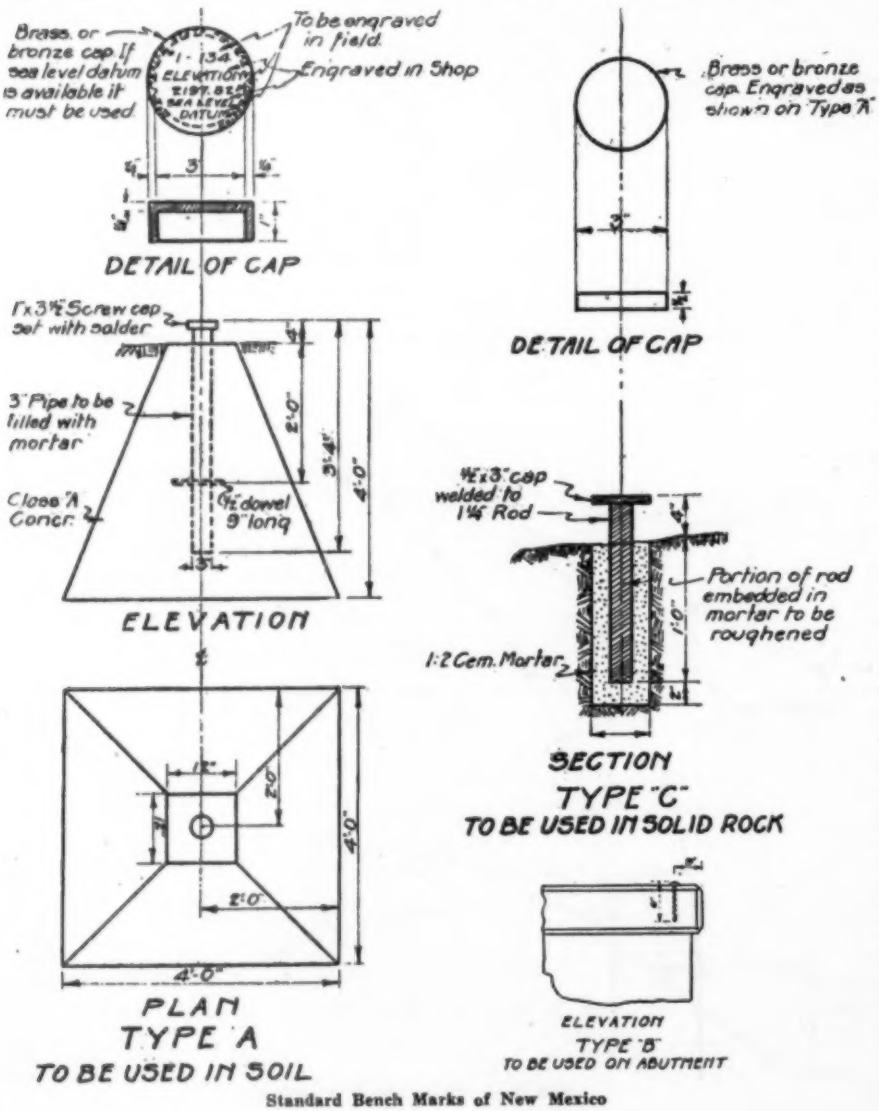
From Highway Location and Surveying, a Michigan Highway Department Field Mannual

Every highway engineer should learn all he can of railroad location. The books on this are fairly extensive, while those on highway location are few and are not general enough to cover the problems of various parts of the country. This literature will teach the student the underlying principles, but the actual field work can only be learned by experience. To make a successful locator a man must have a highly developed sense of direction and an exceedingly good memory of geographical locations. He must not get confused in directions and must always know where he is on the ground. A compass will keep a man on a certain predetermined course, but a sixth sense is necessary to keep properly correlated all of the things seen. He must be a keen observer. This is a very important qualification because all knowledge of a locality depends on this power. He must be a student of physical geography, for upon this depends his ability to familiarize himself with the general features of the topography, such as streams and drainage systems, location of marshes, ridges and divides, stream crossings, etc. He must have a knowledge of the principles of geology, and in Michigan a thorough knowledge of Glacial Geology will be of vast benefit.

Above all else the successful locator must have imagination, as vivid as the child who becomes a sea captain in his mind and brings his ship into port, from the far side of the bath tub, laden to the hatches with the weath of foreign lands. Without imagination nothing is accomplished, for all things are built in the mind first. The locator must be able to imagine and visualize the road winding over the countryside with the cuts and fills made, the bridges and culverts built, even to the guard rail all nicely painted. If he can do this he can see how the hills lie for desirable alignment and grades. He can see if the stream crossings are practical, and he can compare by the aid of maps which he has made the desirable and undesirable physical features of the different routes he has under consideration. So much for the natural features with which he has to contend.

There are many other things which he must consider. He must consider the relative cost of various routes, both as to construction and right of way. This involves a knowledge and experience on actual highway construction. He must consider the effect the remainder of the system may have on his location; the junction with other trunk lines and with subsidiary roads; the desirability of going through or around important cities or villages. He must consider existing improvements. When one starts to consider a highway routing he keeps running from one problem into another until first he knows he has reached the limits of the state. This explains the long projects considered.

Some of this may seem superfluous for a highway engineer's handbook, but if it will fire the ambition of men to study all the problems hinted at and find others for themselves it will make real locators of our chiefs of party instead of mere surveyors. Often instructions as to route are sent out from headquarters office which are designated from a map knowledge, backed by superficial observation, which in the main are correct but which may often be greatly improved in detail. Because a certain line is designated on a map is no reason for a chief of party to accept it in the "sundown and payday" attitude. He should satisfy himself that it is the best and if he cannot do that he should call it to the attention of the Engineer of Surveys and Plans.



Standard Bench Marks of New Mexico

Recent Developments in the Highway Construction and Maintenance Field

Abstracts of Papers Presented at the 1928 Convention of American Road Builders Association

Road Construction in Alaska

By M. D. WILLIAMS
Acting District Engineer of Alaska

THE entire area of Alaska is 490,000 square miles; the coast line is equal to the distance from St. Augustine, Fla., to San Diego, Calif., with hundreds of miles of inland waterways; the climatic conditions vary from a temperate climate, neither as cold nor as warm as at Cleveland, O., with a normal differential of 80 deg., to the extreme arctic conditions of very hot summers and very cold winters with a differential of 170 deg.; an annual precipitation varying on the coast from 20 to 130 in. and a snow fall of a few inches on the coast to 20 ft. in the interior and on high intermediate mountains; a vegetation varying from a semi-tropical wild growth on the southeastern coast to a sparse tundra growth of a few inches, underlaid with perpetual ice, in the interior plateau; elevations varying from 3,000 miles of coastal territory at sea level to an immense plateau of from 2,000 to 5,000 ft., with an intermediate mountain range with elevations up to 20,000 ft. and a dozen peaks equal in elevation to Pikes Peak in the Colorado Rockies; an archipelago comprised of thousands of islands varying from a few square feet to a million acres—all heavily timbered interspersed with navigable waterways.

Conditions in Southwestern Alaska.—In southeastern Alaska all towns are separated by unbridgeable waterways, and of the ten larger towns in this area only three are on the mainland. This condition necessitates all travel by boat. Southeastern Alaska is well served by commercial passenger boats and the Bureau of Public roads owns and operates a power boat large enough to handle equipment and men required on surveys and construction. As may be assumed from the areas and distances given, the interval between projects is often very great. As an instance the Bureau last season operated two construction jobs 1,800 miles apart, under the direct supervision of one office and inspector. With the great distances involved and all travel by water on boats varying from 10 to 20 knots per hour, time is an important factor in all undertakings.

Gravel Road Highest Type.—No road construction has progressed beyond a gravel surface type. Three distinct characteristics for grading are offered by locality. On the coast practically all work is near or parallel to the coast lines, through heavy timber, with enormous quantities of down and partically decayed growth forming a heavy duff. The heavy precipitation results in a saturation to gravel or to solid rock and large areas of muskeg or mountain swamp result.

The saturated condition of the ground makes the use of heavy equipment impossible. A finished grade will support no traffic except on such portions as are on solid rock until a top surface of some type has been applied. In practically all cases subgrades are allowed to settle and drain for one year before an attempt is made to apply surfacing.

Surfacing is available in large quantities adjacent to glacial streams and on ocean beaches and is often of such a character as to permit its selection and use without screening. When such material is not available, crushed rock is used, the cost of beach and glacial gravel on the road being approximately $2.50 and of crushed rock $4.00 per yard.

Corduroy Grade.—It is often necessary to use long stretches of corduroy which is placed on the grade, buried to a depth of at least 6 in. and the surfacing material applied on the grade so prepared, resulting in a floating roadway of sufficient carrying capacity to support 2 to 3-ton trucks. Traffic, however, is in general confined to light cars and small trucks.

Costs are greatly affected by clearing and grubbing operations which vary from $200 to $1,500 per acre. One job recently constructed was cleared by means of donkey engine on a large log float in salt water. Practically all excavation is by hand and contractors work with stationmen using pick and shovel and dump cars.

Excavation costs will average $.80 to $1.00 for common and from $2 to $4 for solid rock. All duff removed is included in quantities for common and measured prior to grubbing.

Conditions in Interior.—An entirely different condition is met in the large open plateau country of interior Alaska. Here clearing is not to be considered as the major item as there is but very little timber, all of which is small and easily removed. The problem of securing a subgrade still exists and is met in various ways. A large portion of the country is covered with tundra, a growth composed of many very small bushes, etc., with a mat of roots from 12 to 18 in. in thickness. The entire country is underlaid by frozen ground. During the summer season the ice line is lowered to from 2 to 5 ft. below the surface and to a greater depth if tundra is removed and surface loosened. Long stretches of road have been built by removing tundra one season and grading the next by means of tractor and blade. Deep ditches are cut, the material being thrown into a rough turnpike and allowed to drain. Surfacing is then applied. Usually a glacial gravel is used without screening and larger stone removed from the grade. One of the most important problems to be met in the interior is the crossing of the many glacial rivers encountered. These streams carry an immense amount of material, are very wide, are subject to many heavy floods and are constantly changing their channels. Practically all interior roads are build by some form of stage construction which does not look to a completed road for from 2 to 4 years.

The Richardson Highway.—The Richardson highway has been under construction for many years, first a rough trail, later a passable freight road, and at present a very satisfactory gravel surfaced motor road extending from the coast to the Tanana valley, 400 miles inland. This construction has been and is handled by the Alaska Road Commission under the direction of the War Department. This organization handles road and trail work in the territory, except such as is within the national forests, and expends annually approximately $1,000,000 of federal funds.

The maintenance and construction of all roads during the winter months also offers a number of unusual problems. First, the very short period of daylight practically precludes all construction should weather conditions permit, and in the higher and inland portions of the territory glaciating of small streams and heavy snow fall make snow removal and winter maintenance impossible, with the result that travel on such routes is discontinued or reduced to dogs and sleds. On the other hand, coast roads are open at all times, although maintenance is made difficult because of the varying frost conditions in the saturated subsoil.

Coast roads which are practically all within the national forests are con-

structed and continuously maintained by the U. S. Bureau of Public Roads under the Federal Highway Act. Approximately $500,000 of federal forest funds are expended annually by this organization in cooperation with the territorial board.

County Highway Financing

By JOHN J. McHUGH
Secretary Association of Chosen Freeholders of New Jersey

Where can we buy money the cheapest?

No, this is not intended as a trick question.

Instead, it is the crux of the whole question of financing.

When we borrow money to build or reconstruct highways, or for any other purpose, we are buying money. In that sense money is a commodity. And the more alert among the county officials are today learning to buy money as cheaply as is possible. In other words, on the best terms obtainable.

It is, of course, to be understoood that in considering cheapness the lowest cost in the long run, is the prevailing factor.

How It Is Done.—Borrowing the needed money at the lowest expenditure of interest charges, and retiring bonds in the shortest possible time would seem to be the best way to finance county highway construction. How is this accomplished, you ask?

Here is a brief summary of the necessary details. Not theoretical but in actual practice.

When the original resolution or ordinance authorizing the improvement is adopted, the type of highway to be constructed, or reconstructed, should be clearly specified.

This is important if good faith is to be shown. The various types of highway construction have each an agreed upon "life" or period of usefulness. It is certainly not good financing to attempt to borrow money or issue bonds for a longer period than the probable "life" of the particular highway under construction.

Probable Life.—Here is a schedule of the probable "life" of various types of highway construction which is working most satisfactorily in many of our counties:

For construction and reconstruction of bridges, including retaining walls and bridges of stone, concrete or iron construction, or of a combination of any or all of these materials,—30 years. (Bridges included in this schedule because they are deemed to be properly a part of highway construction.)

For various types of highway construction as follows:

Of sand and gravel—5 years.

Water bound macadam or penetration process—10 years.

Bituminous concrete construction—15 years.

Blocks of any material or sheet asphalt laid on concrete foundation—20 years.

Concrete construction not less than 6 in. thick—20 years.

For the acquisition of lands for highways or for eliminating curves or for grading, or for any or all of such purposes—30 years.

For construction of grades, sidewalks, gutters, of brick, stone or concrete, or for any or all such purposes—10 years.

Appropriating Resolution.—Then, adopt a resolution, ordinance or other authorization providing for a sufficient appropriation of funds to meet the cost of the work, plus the necessary fees for engineering, inspection and other proper incidentals.

Ordinarily such authority should be granted after the bids for the work have been received, but before the contract is awarded. In States where the law or practice demands that the question be submitted to popular referendum, waiting until the receipt of bids will not be practical.

The appropriating resolution covers the legal necessity for having provided for funds. It should provide that the moneys required be raised by the issue of temporary bonds, or notes, to be issued from time to time as required. It will be readily seen that in following this plan of issuing the temporary bonds, or notes, from time to time as required, that a considerable saving of interest will result when contrasted with the other plan of issuing the total amount of bonds or notes required all at one time.

Incidentally, if saving in costs of construction are effected as the work progresses, too much money will not have been provided.

The Bonds.—Then, when the total cost of the improvement has been ascertained, the permanent bonds are issued. These should be serial instead of term bonds. It is admitted that this point is controversial. But, it is submitted that term bonds with possible misuse of sinking funds have provided much cause for just criticism. Under the Serial plan, annual payments retire a certain number of bonds every year. This automatically reduces the interest charge.

The payment of the annual installments and the interest charges is, of course, provided for in the county tax budget each year. That is, unless there is to be an assessment against abutting property benefitted by the improvement.

In determining the sale of the permanent bonds, local conditions must determine the rate of interest to be paid. It has been found to be much more satisfactory to pay a slightly higher rate of interest because of the higher premium paid by the bond buyers. And to provide against any misuse of such premium in advertising the sale of the bonds, notice should include the statement that the total amount of money necessary to be raised is $————, and that the bonds will be sold to the bidder offering to take the least number of bonds plus the greatest additional sum,—so that this may be clear, we will say that the amount to be raised is $500,000 and that the bonds will be issued in multiples of $1,000, and one bidder offers to take $470,000 of the bonds and pay therefore $500,000.99,—the second bidder offers to take $471,000 of the bonds and pay therefore $500,999.99, obviously the first bid would be the highest and there should be a further proviso that the bonds to be delivered should be those first to mature. In the example just cited, the thirty bonds last to mature will be destroyed and the greatest amount of interest saved.

The foregoing only covers, of course, that part of the question of county highway financing, chargeable solely to the county.

No mention has been made of the various plans in vogue in different states for "State Aid to Counties" for financing of highways and bridges, nor of the Federal Aid plan to states.

These have been omitted because the understanding of this committee was that our duty was to suggest a desirable plan for financing purely county projects.

Rural Highway Maintenance in Maury County Tennessee

By F. B. WILKES
Superintendent of Roads, Maury County, Tennessee

We have approximately 1,000 miles of roads, 75 miles are maintained by the state, of which 42 miles are paved. The other 925 miles are maintained by the county.

Available Funds.—One hundred miles of the principal roads, designated by our law as special highway, are maintained by a fund amounting to $150 per mile raised by a wheel tax on autos and trucks. For the 800 miles of district roads we have an advalorem tax on property amounting to $25 per mile. In addition we have a commutation tax on men from 18 to 50 years of age, and a tax on wagons, totaling $30 per mile, but a large per cent of this tax is worked out. We also have a bridge tax for the construction and maintenance of all spans 12 ft. and over. In 1924 we began the expenditure of a bond issue of $1,500 per mile on the 100 miles of special highways. This amount, of course, was inadequate but it enabled us to re-locate some portions of the roads and build permanent culverts, remove rock from ditches, grade and do some metaling. This gave us a start to better conditions which we have been able to continue by constructive maintainance.

Dragging.—We have discontinued the use of teams to a great extent and are using motor patrol, having two 1-man motor graders and a 4-blade maintainer pulled by light tractor. These machines can cover 10 to 20 miles and return depending on conditions. When using the maintainer we make a round trip pulling material to the center of the road, then we take opposite side of road and lightly push this material off distributing it on shoulders. This gives a double working and at same time lessens tendency to high crown. With the 1-man graders we

pull material to center and make one round pushing off, getting over each section once in about two weeks. We follow every two or three months with the blade grader pulled behind a tractor to open ditches. We are able to follow above plan very consistently through winter and early spring months but fall behind in summer when we are compelled to give much attention to district roads. About once each year we find it beneficial to scarify and re-shape with the heavy grader. With the travel we have, averaging 200 to 400 vehicles per day, a coat of gravel or chert will last about five years. We are fortunate in having an abundance of creek gravel and chert. We haul this material with dump trucks at such times as these trucks are not in use on district roads. This material costs 10 ct. per yard at bank, and from 25 to 75 ct. to put on the roads. All loading is done by hand. In addition to the above mentioned equipment we have three caterpillar tractors with graders, plows, scoops and air drills, etc., that are available for heavy work.

District Roads.—On our district roads our funds do not permit any regular system of patrol maintenance. A large per cent of the commutation and wagon tax, above referred to, is worked out by the individuals, as the law permits. This system is not at all satisfactory, for several reasons. The work must be done at a time when the farmers are not busy regardless of needs or condition of road. As the class of work the farmers are best equipped to do is hauling metal, we are endeavoring to use the funds at our disposal on these roads for removing rock from ditches, heavy grading and culvert work. If we can take care of the grading and drainage so that the metal will remain in place with an occasional re-shaping with graders we create a spirit of cooperation that is worth much. During the past year various communities and individuals have contributed a great deal in work and money to secure the use of heavy graders. Many location changes are necessary to remove roads from creeks and to get better grades and alignment. Our progress seems slow but looking back five years there is a great improvement in conditions. The public is gradually turning from the old methods and is realizing that to have roads passable twelve months in the year will require business methods. These statements may seem slow and backward to many officials in the more advanced counties but these conditions do exist in a great many counties, in this and other states. Some are in even worse condition. We are striving for a system that will allow us to work on a cash basis with sufficient equipment to constantly improve conditions.

Work House.—One of the greatest assets in road work this county has, is the county work house under the supervision of a very competent superintendent. Our number of prisoners range from 15 to 25. The work house is located on a 3½ acre lot owned by the county near its center, so it is possible to reach any section of our work. We use these prisoners to load gravel, chert, rock, etc. We secure a great deal of free hauling from the farmers by loading wagons for them during seasons when they can spare their teams. We have two portable air drills and do a great deal of beneficial work removing rock from ditches. We do as little hand work as possible however, doing work with machinery where it can be done. We work these prisoners in squads of five to ten, carrying them to and from the camp in Ford trucks.

Highway Construction in Mexico

By JULIO GARCIA
Consulting Engineer Comision Nacional Decaminos Mexico, D. F.

The result of all combined efforts in building roads, up to the time of the inauguration of the present federal good roads policy, gave Mexico about 260,000 kilometers: 150,000 being what may be called wide trails, and 110,000 highways proper. The invention of the automobile, and the great advancement, has offered a new solution to our problem of establishing a net work of communication throughout the country.

Present Construction Plans.—The present Federal movement of construction calls for a system that will unite Mexico's most productive regions and important towns. The first two roads built were those from Mexico to Puebla; and from Mexico to Pachuca. This first construction work allowed experimentation in modern methods. It is fitting to remark here of the excellent collaboration and hearty support of Mr. Charles M. Upham, during the period of organization and later in his capacity of Chief Consulting Engineer to the Comision Nacional de Caminos.

The present policy of good roads having been inaugurated, preference has been given first to the construction of the two great routes to Acapulco and to Laredo. The first one of these roads was opened to traffic by President Calles on Nov. 11, and is already—rendering good service; work is being intensively carried on to finish the road as soon as possible. On the road from Mexico to Laredo, work has been continued—throughout the year, and there are more than 300 kilometers opened to traffic from Laredo South—through Monterrey; it is planned to greatly intensify the work on this road next year.

Experience Obtained.—The past two years of construction have—shown the advisability of building good roads, but only of such light type as required by traffic.

For some time the newly opened roads will bear light traffic; penetration macadam and higher types have been eliminated with the exception of —the stretches in the neighborhood of densely populated centers where traffic is heavy. Local materials are being used for surfacing, and the treatment known as Catchenite has been successfully applied on the Puebla and Pachuca roads.

This treatment has stood well the present—traffic and its convenience was made more evident—during last year's extensive rainy season. There was not a single case of washing or erosion, and traffic was never discontinued even during the hardest showers on the mountain sections.

Finances.—A gasoline tax was created for the Federal highway construction fund. Later the revenues from this tax were incorporated to the federal income, and larger amounts assigned on the yearly budgets.

It was not deemed advisable at the time of inaugurating the Federal Highway Construction (1926) to secure any loan for road building. It was considered preferable to start the highway construction on a small scale and with the resources available. After the splendid results obtained with the first routes opened, highways can be easily boosted and the selling of highway bonds will not be difficult.

The federal primary highway system includes 7 principal routes; which construction is considered—rather essential.

County Highway Legislation In New Jersey

By HOWARD B. KEASBEY
County Engineer, Salem County, New Jersey

In New Jersey county highway legislation is of comparatively recent growth. In order to understand the subject it is however desirable to look over the history of County Government.

In the early colonial days (prior to 1715) the county governing body seems to have been the grand jury. They seem to have raised money by taxation and to have cared for the court house and jail. They probably were also charged with the building and maintenance of bridges. In New Jersey bridges which cannot be built with common labor are now county bridges.

About 1715 it appears that the "Justices and Chosen Freeholders" became the county governing body, and the justices ceased meeting with the freeholders about 1715.

The board of chosen freeholders is now the county governing body in New Jersey.

Originally these boards consisted of members each of whom were elected by a township ward, borough or other

district and who represented that district.

In some of the more populous counties the boards became so large, that the "Small Boards" were constituted. These consist of three, five or seven members elected in the county at large.

Any county may by referendum adopt the "Small Board Act." There are still several "Large Boards."

There are twenty-one counties in New Jersey. Owing to the great difference in conditions between the various counties the legislature has designated First, Second, Third and Fourth class Counties.

Powers of Board of Freeholders.—Under the County Act of 1918 (Chapter 185 P. L. 1918) and the Road Act of 1912 (Chapters 395 P. L. 1912) both of which apply to all counties, the board of chosen freeholders have power, to layout, to acquire, to alter or grade, to pave and improve, to drain, to light or beautify and to vacate, roads. The board also has the right to build and maintain bridges or viaducts when and where the public convenience requires. The construction of roads which form a boundary line between two counties and of bridges over streams which form a boundary line are also provided for by joint action.

The board has also the right to condemn land for either roads or bridges.

The board is required to adopt a budget during January of each year, in which the amount necessary for these and other purposes are set forth. Also the anticipated revenue from various sources, and the amount to be raised by taxation.

Financing.—The board also has the power to issue bonds for any purpose that it has a right to make a budget appropriation. All bonds, however, must be serial bonds and must be paid within the period of usefulness of the public work for which they are issued. The period of usefulness for the various public works is stated in the act. These bonds must be sold after proper advertisement.

The board has also the power to issue temporary loan notes. These however, must be retired within six years.

The board has also the power to borrow in anticipation of taxes. Such notes must be paid within six months.

The board has power to make contracts for construction and maintenance work or for supplies. Contracts in excess of $1,000 can only be made after advertisement for bids.

The board has also the power to do work by "force account" or day labor.

The board has also the power to operate a prison road camp. To this camp are sent only the county prisoners with terms of six months or less.

In New Jersey originally all roads were maintained by the city, borough, township or other municipality.

During the latter part of the 19th century, acts were passed which enabled the counties to build certain roads.

Three Classes of Roads.—About twelve years ago the state highway system was started, so that today we have three clases of roads.

1st. The road maintained by the local municipality.

2nd. The county road.

3rd. The state highway.

The board of chosen freeholders can take over for construction and maintenance (with the consent of the local municipality) any of the roads first above mentioned.

To build and maintain the county roads the board of chosen freeholders have the amount raised therefore by taxation. Also an allottment of motor vehicle funds made to them by the state highway commission. These motor vehicle funds are raised by license fees. There is a tax of 2 ct. per gal. on gasoline. The money raised by this tax is devoted to the state highway system.

The board of chosen freeholders is also empowered to select a county engineer with a term of five years. Also a county supervisor of roads with a like term.

These laws have enabled the counties in New Jersey to build up a capable and efficient force for the construction and maintenance of roads and bridges.

Depreciation of Road Contractors' Equipment

By W. R. SMITH
President of the Lane Construction Corporation

The investment in road contractor's equipment has grown amazingly in the last few years. Purchase of plant and its sad depreciation nearly make the road-builder's business look foolish or hopeless, as you like. After 26 years as a corporation, our expenditures for plant the past season are the greatest in our history. This investment is due not to a marked increase in volume of business but largely to changed ideas of the dominating engineer. Our ancestors built roads around the hills except in the case of a few old post roads. The present tendency of design is to go through the hills regardless of the ledge that may be encountered. In the same length of project thousands of yards now have to be moved where it used to be hundreds, and it must be done by machinery. The speed at which work is now expected to be accomplished, the necessity for eliminating unskilled labor owing to its inefficiency and high cost, and the continually marked changes in construction methods might also be mentioned as reasons requiring an increased investment.

Life of Equipment.—In regard to the varying life of equipment—we have a steam roller in use 20 years old. We have ten steam rollers 10 years old. Our veteran shovel is eight years old but has degenerated to craning use. From three to four years is our expectancy in the life of paving mixers. Air compressors, air drills, etc., also have a short life.

One way to get at depleted values is to offer old plant in trade for new. A machinery salesman will give a more or less true value on the old equipment that will surely show depreciation.

Loss of Small Tools.—While small tools are not on our plant list, they are a real cost and a real loss. This year we purchased, among other tools:

2,083 lanterns.
2,150 shovels.
443 picks.
332 pails.
141 wrenches.

Most of which are now ruined, strayed, or stolen.

The Associated General Contractors of America have copywrighted a construction equipment schedule showing expectancy of economic life of plant, depreciation, and other items of annual expense on equipment. This schedule in our opinion can well be followed in reason.

Human Element Factor in Depreciation.—You men who are close to your equipment know what a factor the human element is in depreciation. A poor runner will take more out of a shovel in one year than a good man will in three. Do we follow our operator as closely as we should?

The man whose work is largely confined to his own city or home locality has a comparatively simple problem in checking depreciation in the proper care of his plant. To those of us who work over a somewhat more extended territory the problem is more complicated. Our plant at present is located in fifty three towns in seven states.

The checking of depreciation by proper care of plant presents one of our most difficult problems. For years an attempt was made to house heavy equipment, but now all plant of size, except trucks and autos, is left in the open. We maintain repair shops at different points where winter repairs are made, but the volume of plant shipped in and out of these shops, except auto equipment, is comparatively limited.

Plant Supervision.—We are continually trying new methods of plant supervision to prevent depreciation. Last year we purchased a truck, called by the men "The Covered Wagon." This truck was operated by two men—one a gas engine and the other a steam engineer. Tools for making repairs and some repair parts were loaded in this truck to its capacity. It then started on the round of different organizations, making repair at the order of our master mechanic. In order to avoid friction with superintendents as to cost of repair, all expense of this truck was made a General Repair charge and not a charge against the immediate job where the work was done.

The Traveling Master Mechanic.—

This year we conceived the idea of a master mechanic, traveling steadily from one organization to another with authority to suggest repairs on plant as might seem in reason to him, the list of repairs being turned over to the superintendent in charge. If the superintendent in charge thought the repairs unreasonable, he could appeal to the decision of one of our division engineers who could arbitrate the matter. Our men are very jealous about the repair charges going against their cost. The mechanic's reports include to the superintendent any abuse or improper use of plant which he may discover in his travels. Our master mechanic's car, carrying parts catalogues of the greater portion of our equipment, covered something over twenty thousand miles this last season.

Methods of Figuring Depreciation.—Regarding different methods of considering depreciation, I would refer you to a paper recently published written by A. H. Hunter, Field Engineer of the Illinois Association of Highway Contractors. This paper was most ably conceived and well thought out.

A proper plant account should show original cost, a value at the opening of the year, and a further depleted value at the close. To determine sales values, it is most desirable to have a reasonable book value. We do not believe in a flat percentage for depreciation, the varying life of plant being such a factor.

A dominating factor in the cost of plant depreciation today is the federal government. If an unusually clever contractor can show a profit on his business he is then lined out for an argument as to what is legal depreciation. This situation becoming more or less acute, the Associated General Contractors of America appointed a committee to confer with the treasury department of the federal government to determine reasonable depreciation for income tax purposes.

The treasury department of the federal government on February 19th issued a questionnaire entitled "Outline for the Study of Depreciation and Maintenance in the General Contracting Industry by the Bureau of Internal Revenue with the Cooperation of the Associated General Contractors of America." I will give you the items of the questionnaire and our replies to the same:

1. Each major item of equipment is depreciated individually at an appreciable rate rather than collectively at a composite or average rate of depreciation for a group of items.

Ans. In our practice we have always depreciated each piece of equipment individually taking into consideration obsolescence, climatic and other local conditions affecting same.

2. The assessed value of each item of equipment is reduced by the amount of depreciation accrued so that the annual balance sheet will show only the aggregated depreciated value of equipment.

Ans. Our practice is in strict accord with your formula.

3. Profit or loss on disposal of equipment is determined as the difference between the depreciated balance sheet value and the actual salvage value.

Ans. It has been our practice to increase or decrease the total depreciation by the profit or loss arising from sale or salvage.

4. Depreciation on an item of equipment is never accrued to exceed the initial cost of the item.

Ans. Our practice is in strict accord with this formula, and we take no depreciation below the turn-in value of an article where such a valuation has been established.

5. The cost of replacing worn-out or broken parts of equipment is charged to Current Expense as Repairs and Maintenance.

Ans. Our practice is in strict accord with this formula.

6. An estimated salvage value is not deducted from the initial cost to determine a cost subject to depreciation but the entire initial cost is subject to extinguishment by depreciation, in which event all salvage realized will be reported as a profit.

Ans. Our practice is practically in accord with this formula.

It should be the contractor's hope that a definite policy can soon be reached and the problem solved.

It is impossible to stress too strongly the importance of depreciation as a factor influencing the business success of the highway contractor. The following illustration will give an idea of the cost of depreciation:

Equipment Used on 5¼ Mile Contract.—On a contract with the State of New York for a concrete road 5.24 miles long, amounting to $265,000, we used the following equipment:

2 Steam Shovels.
1 Paving Mixer.
1 7-S Concrete Mixer.
2 10-ton Rollers.
1 5-ton Roller.
Water Pipe.
3 Gas Pumps.
Forms.
Batching Bin.
12 2½-ton Trucks.
4 Ford Trucks.
1 Concrete Finishing Machine.
1 Crane.
1 Belt Unloader.
2 Fordsons.

The total original cost of this equipment was $128,000. If new equipment had been used, depreciation, following largely the Associated General Contractors' schedule previously referred to, would be $35,000 for the first year.

The fact that the elements of depreciation are inclined to be subtle, and therefore very readily misunderstood or underestimated, magnifies the importance of the subject. There have been numerous instances of failures of highway contractors which may be traced directly to lack of appreciation of this vital factor. An intensive study of this subject unquestionably is an essential to the success of any venture in highway construction.

Cotton Fabrics Used in Bituminous Surface Treatment

A new use for coarse cotton fabrics in the construction of improved country highways has been reported to the New Uses Section of The Cotton-Textile Institute, Inc. The fabric in this instance provides a "membrane" that is imbedded in the materials used in surfacing the road.

During the past year experiments have been made in South Carolina under the direction of Charles H. Moorefield, State Highway Engineer. In order to test the practicability of this new use of cotton, Mr. Moorefield selected a section of state highway in Newberry County, S. C. This was known locally as a top-soil road which consisted principally of small size gravel with a mixture of sand and clay as binding material. On it a bituminous surface treatment was applied.

The first step in this process was to scarify the surface of the road. As it gradually rebounded under traffic the surface was kept smooth by the use of scrapers or drags. Then a prime coat of light tar was applied and allowed to "set" partially. The next day an open weave cotton fabric having a yarn count of 7x7 in both warp and filling and weighing approximately 7 ounces per yard was spread over the sticky tar. Hot asphalt of 150 to 200 penetration was then applied to the fabric and the asphalt was covered with coarse sand to give a wearing surface. The road was ready for traffic immediately after the surface treatment had been completed.

In announcing this new use of cotton, E. C. Morse, in charge of the New Uses Section of the Institute, stated:

"After nearly a year, this section of improved highway shows very little, if any, wear. When engineers made an examination recently they found the cotton membrane was performing its function admirably. The materials used in surfacing the road had been kept in place and there was little tendency for 'duck nests' or holes to form in the road."

Handling 6,000 Automobiles Daily While Paving Road

A state highway paving contract in California, having a number of interesting problems, was completed late last year. The work was on the Rincon Road, extending from Ventura, Calif., to Benham subway, 12.5 miles. J. F. Knapp, Stockton, Calif. was the contractor. The most important of his problems was that of carrying on the paving work expeditiously and keeping the road open to traffic at all times. How the traffic was handled is described in December California Highways and Public Works, by C. N. Ainley Resident Engineer, California Division of Highways.

Detours could not be arranged, as the highway lies between the Southern Pacific tracks paralleling the beach and closely hemmed in at many places by bluffs and hills. Thus it was necessary to pave half the roadway at a time and keep the other half open to traffic. As from 4,000 to 6,000 vehicles daily traverse this section during the summer months, the difficulties of keeping the ordinary traffic moving were enough without adding to them. It was this situation which impelled the contractor to use an industrial railway for handling materials between the

bunkers and the paving mixer so as to keep his trucks out of the controls as much as possible. While it was necessary to shift the track from one side of the road to the other and to cut out a bed for it in places on the railroad right of way, use of the industrial railway was a big factor in the successful handling of the job, both from the standpoint of economy and of facilitating operations.

The handling of the heavy traffic through this contract with as little inconvenience and delay to the public as possible, was quite a problem. In the early part of the work, while the grading was going on, the mud and sand had to be heavily surfaced with rock to carry the heavy trucks and trailers. Heavy trucks, often underpowered and overloaded, and with trailers, were continually getting out of the beaten track, often tying up the traffic for hours. It was necessary to keep a tractor handy at all times to pull them out.

With the coming of summer there was a large increase in traffic. The usual accumulation of cars, during the hours of heavy traffic, and a long control, was 60 to 100. On Sunday the accumulation was 100 to 200 cars. On May 30, Decoration Day, with a long control, the string of cars was two miles long at times.

At the beginning of the work, when it became necessary to put sections of the road under control with one-way traffic, flagmen were put on at each section. When the flagmen were situated so that they could see each other, signals were used, but at other sections a flag was used which was given to the last car to be handed to the flagman at the other end. The method of passing the flag on the last car with a long control and heavy traffic, which included slow moving trucks, was very unsatisfactory. Some drivers unfamiliar with the system would try to hand the flag to everybody along the road, others would forget to hand the flag back and carry it on, and others would deliberately throw the flag away or carry it by. This caused many delays. When the flag did not come through on time, there was always a doubt as to whether the flag was lost or a truck was broken down or traveling slowly. With several sections under control, so that there would be several stops and often delays, there was considerable dissatisfaction and complaint.

The system was then changed and one long control put on which included all the short sections, and a riding flagman put on to carry the flag on the last car instead of giving it to the driver. There was an immediate improvement in traffic conditions. Traffic was speeded up, and the annoyance of numerous delays eliminated. If there was a blockade in the line, the riding flagman went ahead to straighten it out. It was convenient to have several of the flagmen deputized and wear badges, but it was found that men could not be deputized indiscriminately without causing trouble.

Actual length of the pavement built was 12.2 miles, part of it being "second story" with an existing 15-ft. concrete pavement as a base and part of it new construction. The standard width was 20 ft., which was increased to 30 ft. behind seawalls. In connection with the paving two new seawalls were built, one 510 ft. and the other 558 ft. in length, and the old seawalls constructed in 1914, were extended and raised to provide better protection to the highway and to the traveling public.

This contract was in charge of S. V. Cortelyou, division engineer, Division VII, with headquarters in Los Angeles. C. N. Ainley was the resident engineer. Ezra Kaufield was superintendent on the job for the contractor, J. F. Knapp.

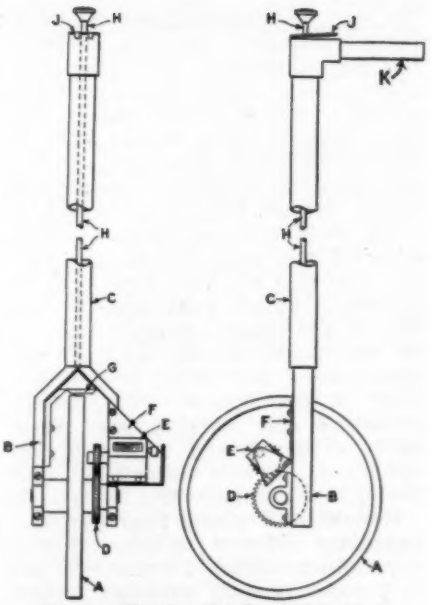
Instrument for Measuring Cracks in Concrete Pavements

An instrument for use in measuring the length of cracks in concrete pavements and with which measurements can be made rapidly and with a satisfactory degree of accuracy, recently designed by the Division of Tests of the Bureau of Public Roads, is described in the December issue of Public Roads. The instrument was made for use on concrete surfaces in making condition surveys in connection with subgrade studies and to determine the effect of various features of design.

It is thought that a description of the instrument may be of interest to state highway organizations and other agencies who are making condition surveys. Such a study of concrete pavements usually begins with a determination of the amount of cracking which has occurred, and if carefully done with a tape involves considerable painstaking labor.

The apparatus, which embodies the same principle as the chartometer used for measuring distances on maps, consists of a wheel which is rolled along the surface to be measured by means of an operating handle. The circumference of the wheel being known, it is so geared to a revolution counter that for each linear foot of travel one unit is recorded on the counter. Thus the reading on the counter at any time shows the total distance over which the wheel has been rolled.

Before giving a detailed description of the device, it may be well to discuss its usefulness. One man with the instrument can replace two men with a tape and obtain the same data more easily and it is believed more accurately. A second advantage is that the actual length of meandering cracks can be accurately measured, something which can not readily be done with a tape. Calibration tests with one of these devices indicated that lengths



Drawing Showing Details of Apparatus

measured at the speed of a man walking were accurate to within 0.25 per cent or 1 ft. in 400. A check on the individual measurements is available at all times in the total on the counter which will record nearly 20 miles before clearing.

The details of construction are shown in the drawing. A steel wheel, A, whose circumference is exactly 2 ft., rolls freely in bearings supported by the forked frame, B, attached to the tubular handle, C. A pair of spur gears, D, rotate the spindle of the revolution counter, E, twice for each revolution of the measuring wheel, A. Thus for each distance of 1 ft. traversed one unit is registered on the counter. The counter, E, is supported and protected by a guard bracket, F. In transporting the apparatus from one place to another it is desirable to prevent rotation of the counter spindle. For this purpose a rubber brake shoe, G, is provided and this is pressed against the measuring wheel, A, by the rod, H, which terminates in a knob at the end of the operating handle. The operator simply presses down on this knob and locks the wheel, the brake being held in contact by the latch, J. To release the brake a slight pressure on the end of the latch, J. frees the rod, H, and permits the wheel, A, to again roll freely.

The operation in the field is so simple and obvious that it needs no description.

Santiago, Chile, to Repave.—A law providing for the repavement of the streets of Santiago, Chile, has been promulgated by the Minister of Interior. The law authorizes a bond issue of 40,000,000 pesos guaranteed by the state bearing not less than 8 per cent interest. Engineer Alberto Veliz, Director of the Santiago Municipal Public Works, Santiago, Chile, has been appointed Chief of the Commission.

Reconstructing Old Highways to Meet the Present Day Requirements

Type and Present and Probable Future Requirements Design Discussed from Standpoint of Capacity Existing

By H. S. PERRY

Assistant Chief Engineer, Bureau of Maintenance, Ohio Division of Highways, Columbus, O.

The reconstruction of old roads to meet the requirements of present day traffic is one of vital importance, involving as it does the problems of major financing and careful designing to meet probable future requirements. In his paper presented at the 14th Annual Purdue Road School, which is reprinted herewith, Mr. Perry, the author, points out some important factors that should be considered.

THE capacity of any pavement of any given width has been both theoretically and practically analyzed. Theorists have evolved formulae which give varying estimates, but are on the whole generally faulty in that they cannot take into consideration the personal equation.

Capacity of Traffic Lanes.—The writer has made many careful observations and has come to the conclusion from these observations, together with a study of the observations of others, that a one lane pavement has a practical capacity of about 450 vehicles per hour; a two lane pavement has a capacity of about 1,400 vehicles per hour; a three lane pavement has a capacity of about 2,000 vehicles per hour; and a four lane pavement a capacity of about 3,000 vehicles per hour. The figures given are exact for a two lane pavement, the actual maximum capacity in this being in the neighborhood of 1,600 vehicles per hour. The figures given for the one lane pavement are meant to cover a single one lane pavement under average conditions of traffic going both ways, and does not represent two adjacent but separated one lane pavements. The figure given for the four lane pavement is approximate, while that given for the three lane pavement is theoretical.

There is little doubt but that 10 ft. is the practical width for one lane and multiples thereof for two or more. In the writer's opinion there is very little excuse for the construction of a three lane pavement, except that it be as a transitional type, so designed as to permit its completion as a four lane or its duplication as a dual three lane pavement.

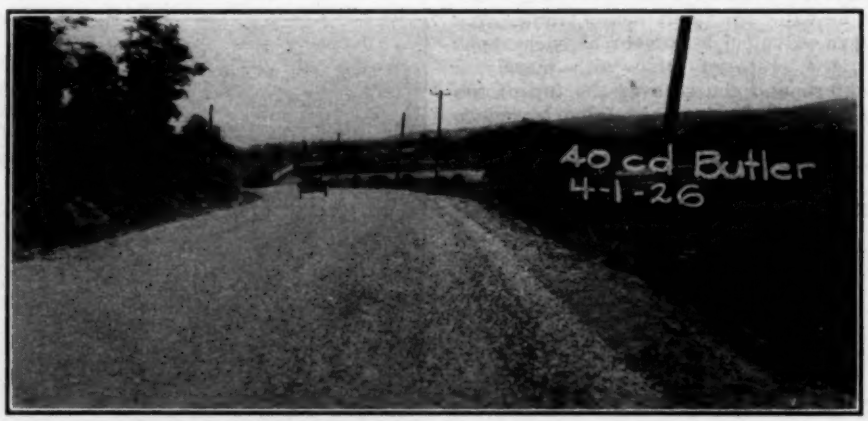
There has been considerable discussion in Ohio with reference to the construction of two twenties as against one forty. The capacity of two twenties would only be 80 per cent of the capacity of one forty. There are occasions, however, where other conditions might intervene, making the two separated pavements desirable; the aesthetic, and the presence of car tracks in the middle space. If this dual type is to be at all safe for traffic, it should be one way on each side. The species known as the three lane pavement is, in the writer's opinion, desirable only near fairly large centers of population where the daily movement of traffic is excessive in one direction at a given time.

Salvaging Old Macadam by New Side Strips.—Numerous samples exist in the east where old macadam has been salvaged through the center with lanes of concrete and brick and other types along each side. In general this type of salvage is practical, especially where the appearance of the surface of the widening is sufficiently different from the appearance of the surface of the central portion of salvaged macadam to secure the desired separation of traffic, although the capacity of the overall width is not so great as it should be if it were all of one type, due to the fact that traffic will generally keep to the right, avoiding the central portion of salvaged macadam, especially when it is not so smooth riding as the widening. In all such cases widening of this character, especially with concrete strips, should be approximately 42 in. or 10 ft. on each side, if proper consideration is given to the requirements of traffic. It has been the writer's repeated observation that the 42 in. strip is sufficient in width for fast as well as slow moving vehicles to keep the right wheels centered thereon. The desirability of the width of 10 ft. is, of course, self-evident.

Center-Lining Pavements.—The three lane pavement should under no circumstances be centerlined for the purpose of guiding traffic. All others should be center-lined, especially on curves both vertical and horizontal and on tangents where traffic is heavy. This center-lining although expensive, is well paid for through decreased accidents and through decreased shoulder maintenance.

Salvage Value Often of Minor Importance.—The salvage value of an existing type is in many cases of minor importance. Probable future traffic requirements should not generally be the sole guide in determining the economy of reconstruction. The use of this word "economy" is frequently misleading. It is here used in its stricter engineering sense and is meant to apply to the final cost of the reconstructed project and not to its initial cost. A road will too frequently be reconstructed at $10,000 per mile where $30,000 would be a more economical investment. This will apply especially on sections where alignment and gradient are both or either faulty.

Roads constructed 10 and 15 years ago were only too frequently constructed without vision, and it is a question of grave doubt whether we are even at the present day doing much better in a great many places. It is difficult to estimate the cost to the traveling public of a year's time in rounding a square turn on a road, even



An Excellent Example of Traffic Bound Development in Butler County, Ohio

This Shows a 36 In. Concrete Curb

of minor importance, over the cost of making that same turn on a reasonable radius. It is idle here to discuss the petty reasons for our failure to properly relocate such a turn. It is only too frequently a lack of stamina rather than a lack of engineering conception.

The same applies to vertical curves of short sight distance, the rest of which is in front of Farmer Jone's barn. The same applies to abrupt grades and to numerous other conditions which tend to increase the hazard in driving.

Remedying the Mistakes of the Past.—The State of Ohio is awake to right of way problems and is doing its utmost to remedy the mistakes of the past in correcting situations arising from the above where extra property is required and in securing extra parallel right of way over the more important roads where widening is soon to become a necessity, or where it is already a necessity but adequate funds have not yet been provided.

It is an economic fact that the less the investment is in the existing type of pavement the less emphasis should be placed upon its salvage value under average conditions.

The macadam type properly constructed frequently has a very high salvage value for fairly heavy traffic. We have salvaged a number of such types in the state of Ohio with merely a waterbound course over the top of the old; others by feather edging to reduce the crown and placing thereon a penetration top; others by a combination of the above with concrete edging for a 20 ft. over all width. It will be well to remember that this concrete edging for a width of this type is not practical for any traffic unless the strip is 36 in. to 42 in. width. It is an economic blunder to construct curbs on this type of less width.

Widening Concrete Pavements.—Numerous blunders have been made in widening concrete pavements. If the existing pavement is 10 ft. wide and in condition considered adequate for 100 per cent salvage value, the widening, if placed on one side only, should be of equal width in spite of the fact that the prevailing standard might be 18 ft. on either end of this one lane section to be widened. There are two reasons for this:—the widened portion of equal width creates central center line, whereas if an 8 ft. strip is placed alongside a 10 ft. the heavy traffic using the 8 ft. strip will drive dangerously close to the joint, materially increasing maintenance and decreasing the probable life of the pavement.

On the other hand if it is considered economically necessary to construct nothing more than an 18 ft. width in this particular instance it will be much preferable to use 4 ft. on each side of the existing 10 ft. rather than to use 8 ft. on one side.

The writer has one 4-mile section in mind widened in this way from 10 ft. to 18 ft. using a 4-ft. strip on each side. This work was completed three years ago. Previous to its completion numerous failures had been occurring in the old 10 ft. section and it was presenting a serious traffic hazard at all times.

The widening contract included a reasonable amount of replacement in the existing 10 ft. section and the result has been that in three years not one yard of concrete has been replaced in this section in spite of the continually increasing traffic.

A concrete pavement to be widened from 16 ft. or thereabouts, to 20 ft. should, if at all possible, secure the widening on one side only, not from the standpoint of first cost but in order to keep traffic away from the edge of the old 16 ft. pavement as much as possible. The same would in general apply to a brick pavement.

Widening Brick Pavement.—It is unquestionably of considerable merit to contemplate the widening of a brick pavement with brick. This would be especially true if the character of the design would agree with that of the existing pavement. It is a psychological fact that traffic desires uniformity in superficial appearance if traffic is to be distributed over the entire driving surface.

A 16 ft. brick pavement widened to 20 ft. with two 2 ft. concrete curbs is still a 16 ft. section. This is not a mental attitude of the writer but is the result of careful observation of a number of miles of this type of pavement existing in Ohio. Ninety per cent or better of the traveling public is never on this 2 ft. curb. The only vehicle which uses it in any large way is the four wheel truck. Trucks with trailers weave a great deal and very very little advantage is secured in this instance. Automobiles never use it.

It would have been a far better investment to have placed a 42 in. curb on either side rather than the 24 in. and in my judgment infinitely better still to have placed a 10 ft. pavement on one side.

Concrete curbs along old brick pavements where the existing curb is gone should be either 8 in. or 42 in. The widening of this type to an additional 10 ft. would undoubtedly serve traffic better if this were of brick rather than concrete.

In case the brick pavement or the concrete pavement to be salvaged does not merit 100 per cent or near that and it is found necessary to virtually discard the same, we in Ohio have found it very frequently advantageous economically to resurface one with the other.

This, of course, would not apply if the concrete or brick were in real bad condition in so far as their resurfacing with brick were concerned. We have found that on resurfacing these types with concrete where the new width is greater than the old, proper reinforcing over the edge of the old pavement, in some cases after three or four years' service, has prevented so far the formation of cracks over the edge of the old pavement.

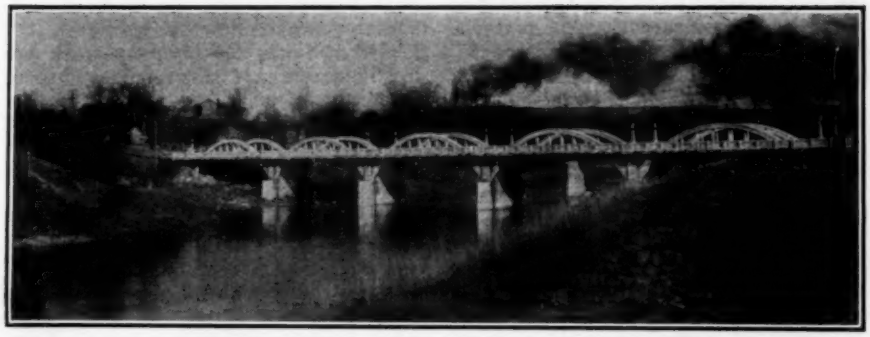
Reconstruction of Drainage Structures.—There are a number of the other factors that should be considered. The prime desideratum of modern traffic is a smooth riding surface. Surfaces presenting depressions greater than ½ in. are objectionable to fast moving traffic. An abrupt depression

This Relocation Improved the Sight Distance

of ½ in creates a heavy impact where heavy traffic is involved. It is hardly necessary to dwell at length upon this item. It is only necessary to compare construction of 1927 with that of 1920. We are frequently prone to construct drainage structures of insufficient width. It is financially excusable to permit a narrow structure to remain where the structure is in good condition and the cost excessive. It is, however, bad practice to reconstruct the average small drainage structure on a two lane pavement without allowing at least 3 ft. on each side in addition to the width of the pavement. It is a common experience that the motorist requires approximately this extra clearance in order not to move toward the center of the pavement as he is passing a drainage structure. In my opinion the structure must be rather expensive indeed not to warrant at least 20 ft. for a two lane pavement.

Lighting of Major Highways.—The development of busses in the next 20 years will prove amazing. In my opinion before this time will have past 90 per cent of all traffic under 100 miles radius will be by bus. Waiting stations, parking places, rest rooms, must be provided at convenient and desirable intervals. Major highways must be lighted to permit the larger useage of the highway. Freight development will undoubtedly follow passenger, although perhaps in not so large a way. If we are to improve the highway properly and are to encourage this line of development, is should be encouraged by the night usage of a lighted highway.

Building of Secondary and Feeder Roads.—Perhaps the largest development of highways within the next ten years will be that of the secondary and feeder lines, if we are to keep down the steadily increasing costs of agriculture and are either to offset the general drift toward the city or to facilitate the transportation of agricultural products to the centers of population. In the carrying out of this idea it must be borne in mind that in building roads of this character, whether they be secondary roads on the state system or other light traffic roads, the mistake should not be made in creating a type



Standard Arch Construction Over the Great Miami River

in excess of the requirements of traffic for perhaps ten years to come. We, in Ohio, have made some mistakes in the development of this type of road in that we have not gone carefully enough in some instances in the construction of a satisfactory grade. Any road that might be expected to carry as much as 200 vehicles per day by 1930 should have a grade constructed that will permit of a more durable type of improvement to be placed upon the temporary improvement to be constructed on the secondary and feeder systems.

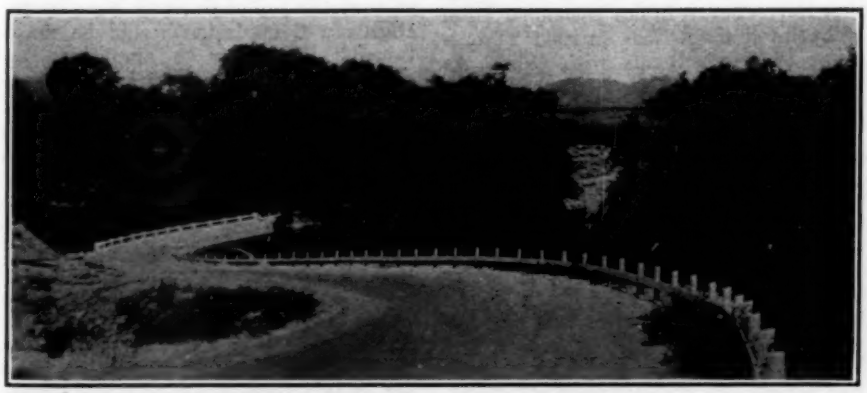
Roads that will not carry more than 200 vehicles by 1935 should fall within the class which need not have particular attention given to the subgrade or to certain other features of gradient or alignment. It is true that there will be exceptional cases where excessive costs might be incurred at special points. These locations might temporarily be passed up and the situation taken care of by adequate marking to control the flow of traffic.

Increased Traffic Over Secondary Roads.—At the end of 1927 the State of Ohio had on its secondary system of roads approximately 4,000 miles of this type of pavement constructed as traffic bound, in which gravel, limestone, and slag have been used. There is little doubt but that we failed to start as soon as we should have started in this line of development. We have been amazed in a great many instances at the increase in traffic over routes thus improved, where formerly there had been a discontinuous improvement, causing traffic to detour during bad weather. Under the average financial conditions any state will find it difficult to come up with traffic development, if it should be expected to construct a thirty thousand dollar a mile improvement at the start. At the same time an excessive development of the cheaper type where higher maintenance costs are bound to follow might lead to financial disaster from the standpoint of upkeep. On this score I would say that we have endeavored at all times to keep in mind the probable future traffic of any given road and in general place improvements of this character accordingly.

Inferior Grade and Alignment Should Not Be Developed.—On all gaps in roads that will unquestionably be of major importance in the near future the mistake should not be committed of developing an inferior gradient and alignment. We have found that about ¼ in. of material for 100 vehicles daily is worn out annually on the traffic bound type of pavement. It is, therefore, apparent that the surface treatment of this type is an economic necessity after traffic has reached six or seven hundred vehicles per day, as a rule. If we should take into consideration the added convenience to traffic as it increases on this type we can readily see that it might be extremely desirable to surface treat such types especially where they exist as gaps when the traffic is much less than this, and perhaps regardless of the volume of traffic.

We could show you instances where well constructed traffic bound roads surface treated are carrying two thousand vehicles a day as an average for the year at not much greater cost than some of our other types of pavement. It is not unusual to find miles of this type with traffic as high as 1,000 vehicles per day being maintained at an annual cost of $500. It is easy to understand that a great many miles of the traffic bound type could be constructed by counties and townships annually on their feeder roads with narrow roadbeds and narrow surfaces amply able to carry as much as two hundred vehicles per day without inconvenience and with a maintenance cost running perhaps as low as $200 to $300 per mile annually.

It would be difficult for me to ade-



Sight Distance Improved by Cutting Away Bad Point

quately impress upon you the extreme necessity of conservation of material and adequate blade maintenance of this type of secondary roads. It is just as essential to remember that the requirement of easy riding surface should be met on this type of inferior roads as it should be met on any type of primary roads. This is the most glaring defect of maintenance as ordinarily practiced on secondary roads. The most common mistake made in the past has been in allotting monies for materials placed upon the road and in neglecting to provide consistent and adequate maintenance.

Financing Highway Improvements.—Fiancial conditions are so different in the different states that it would be difficult indeed to draw a line or give a rule that would apply at all generally. It is becoming increasingly true that taxes for whatever purpose will generally be decreased rather than increased. Funds to be provided for highway work come from taxes of one kind or another and it is to be regretted that it is becoming increasingly difficult to provide additional funds to take care of increasing traffic requirements. The limit which property has paid in the past as a direct tax for highway improvement has been reached in a great many instances and perhaps has been exceeded. The general cry has been to let traffic pay its own way. It is too big a problem to be analyzed here.

We, everywhere are behind the development of traffic in both construction and maintenance. One basic principle that might be stated is, that of all funds appropriated for highway work a adequate sum should be set aside for the maintenance of the existing highway structure. Another is that construction work should follow the requirements of traffic.

Any state should have as an economical minimum for highway work a sum captilized at standard interest rates and based upon its total number of motor vehicles at an average estimated value of perhaps five hundred dollars. A figure less than this is not adequate for normal development and maintenance, to say nothing of bridge replacements, grade crossing separations (both rail and highway), widening and reconstructing, and other specific betterments. The one idea that seems most difficult for the average motorist to understand, when the question of increased highway taxation comes up, is the invisible cost to the traveling public.

This invisible cost is due to many causes, such as sharp turns, narrow roadways, hazardous structures, and other conditions, all of which the traveling public must pay, either in suffering their continuance or in a perhaps better way in providing for their betterment. The big problem of the next ten years will be that of adequately awakening the public to the fact that funds for highway work are far in arrears of the requirements of traffic.

A $400,000,000 Special Highway Fund Proposed

A bill authorizing the creation of a special highway fund, providing a total of $407,341,145, to be allotted among the states in the same proportion as the Federal aid funds authorized each year, has been introduced in the House by Congressman Edward E. Browne of Wisconsin.

The unique feature of the measure, which is sponsored by the American Motorists Association, is that it does not add one dollar to the burden of the taxpayers of the United States. The bill providing for the utilization of this huge sum for highway construction, is in addition to the $165,000,000 Federal aid bill already introduced in both the House and Senate, which is known as the Federal aid bill.

The sum provided in the measure is to be obtained by the repayment of French bonds issued after the war covering an invoice of approximately $2,000,000,000 worth of property including road-building machinery which was ordered in June, 1919 by the War Department to be turned over to the Agricultural Department to be proportioned among the states for use in highway construction. Bonds totaling $400,000,000 mature on Aug. 1, 1929, the remainder one year later.

Before the War Department's order for the return of the equipment was received in France, negotiations had already gone too far for the sale of the property to France, at approximately 20 cents on the dollar. The intent on the part of the government, however, was that it should be used by the states in highway construction, and this intent can still be carried out by favorable action on the Browne bill.

A Correction.—In our December issue we printed an article entitled "Treatment of Earth Roads with Oil." As noted in the issue the article was taken from a report of a cooperative study of "Light Asphaltic Oil Road Surfaces," which appeared in the September issue of Public Roads. This report was compiled by C. L. McKesson, Materials and Research Engineer, California Department of Public Works, Division of Highways, and W. N. Frickstad, Highway Engineer, U. S. Bureau of Public Roads. Through an oversight on our part we neglected to give credit to Messrs. McKesson and Frickstad in our December article.

How They Built Roads in New Hampshire in 1792

It is significant that the expression "good old days," is never used with reference to highways, says the December issue of California Highways and Public Works.

But just how bad those days were, again referring to highways, never dawned upon us until the other day we began to delve in a history of New Hampshire of the date of 1792.

Here are some of the things that we discovered concerning highway building methods in that state at that time.

In surveying roads the length of a man's arm to every half chain was allowed for inequality of surface.

In view of the fact that few surveyors were skilled in finding the variation in their compasses by the sun's amplitude, it was proposed that durable monuments should be erected in convenient places on a true meridian, by which all surveyors should be obliged to regulate their compasses. The General Assembly voted down the proposal.

For crossing small streams beaver dams were found most convenient. New roads, therefore, were laid out to accord to the location of the dams built by those useful animals.

The expense of making and keeping roads in repair was generally borne by the inhabitants of the towns through which they passed, though in some instances roads were laid out at the public expense.

It was a custom for those who were at work on the highways to invite travelers to take a drink, and expect a gratuity in return. This custom, however, had largely been abolished in 1792.

Traffic on a California Road 10 Years Ago and Now

In looking through the old files in the district offices of the Division of Highways at San Francisco, the following was found under the date of April 19, 1916, says the December issue of California Highways and Public Works. It is a plea from the Santa Cruz Chamber of Commerce that the newly graded road (the state highway from Los Gatos to Santa Cruz) be kept watered, so that the "splendid work done by the Highway Commission would be maintained." In order to emphasize the necessity of granting their request, a traffic count was kept.

S. A. Palmer, then president of the Santa Cruz Chamber of Commerce, and W. S. Moore, chairman of the Good Roads committee, in the letter reports that count as: 613 automobiles, 32 motorcycles and 29 buggies.

It is not quite definite from the above at just what point on the highway the traffic count was taken by the Santa Cruz Chamber of Commerce. Nevertheless, it is of particular interest at this time to compare the figures

in this old count with the latest check made by the State Division of Highways, coving a 16-hour period on Sunday, July 17, 1927. This tabulation shows that at the city limits of Los Gatos 9,616 automobiles passed during the 16-hour period of the count, while during the same period at the city limits of Santa Cruz, 7,712 automobiles passed the observer.

The 1927 count makes no reference to buggies, indicating that the horse-drawn means of transportation has dropped to almost a negligible factor in present day highway traffic study.

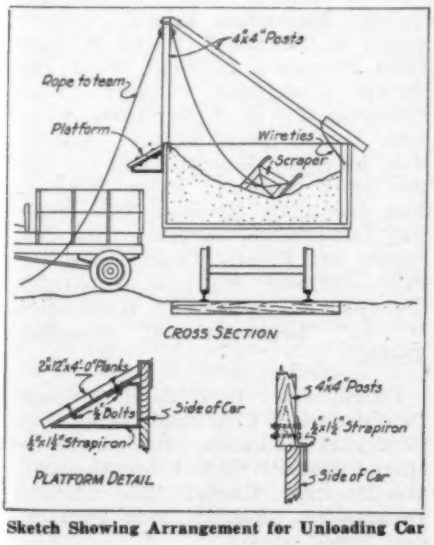
Unloading Gravel from Cars With Scraper

Ordinarily without special apparatus it is a tedious manual labor job to unload gravel from railroad cars where the unloading facilities are not power equipped. At Walton, Neb., recently it was decided to ship in gravel for a large concrete highway bridge and not being able to handle the gravel as fast as it came in with men and shovels, one of the mechanics contrived a device, which is described in the January issue of Concrete Highways.

The arrangement consists of a three poled leg, each leg consisting of 4 by 4 in. material and then bolted together at the top with a ring into which was later hooked a single pulley for the rope. The lower ends of the legs were provided with strap iron strips bent to shape to fit over the edge of the car. A small detachable platform of 2 in. material 2 ft. wide and 4 ft. long was also arranged to hook onto the side of the car directly over the truck to be loaded.

Beginning at one end of the car a team was hitched to one end of a rope and the other attached to an ordinary slip scraper which was placed inside the car and operated by one man. Another man handling the team would at a command from the man within the car, drive the horses forward raising a scraper full of sand up to the sloping shelf. Here it was dumped onto the shelf and the load slid off into the waiting truck below.

As the sand was unloaded the tripod was moved along the car and in this way a full carload of sand was unloaded in less than two hours.



Sketch Showing Arrangement for Unloading Car

Wilford Power Shovel Shows Improvements

The Wilford line of excavating equipment, produced by the Universal Power Shovel Co., provides a full line of units in which the economies of Wilford speed, mobility and Fordson power could be used on contract work.

These units, which have been engineered and brought into production during the past year, enable the contractor to use his Wilford, through interchangeable booms, as power shovel, crane, clamshell, dragline, trench hoe and backfiller.

View of a New Model Wilford Shovel

Wilford contains many features developed by Wilford engineers. Special clutches are standard equipment, as are Timken bearings. All units are now equipped with Eisemann high tension magneto and impulse starter. A specially designed power boom hoist, which is self-locking in any position, is standard equipment on the Wilford crane, clamshell and dragline. This hoist, incidentally, is controlled direct from the single seat, from which one man controls the machine both for digging and for moving. It is truly one-man operation.

Wilford is sold throughout the United States and Canada by a selected group of distributors. Fordson dealers, everywhere, are in a position to render service and secure parts quickly through parts depots in their territory. Many sales have been made in foreign countries, where Wilfords are giving an excellent account of themselves under trying conditions. This shovel is manufactured by the Universal Power Shovel Co., of Detroit, of which William Ford is president.

"In producing this shovel," said Mr. Ford, "our first thought was to build a powerful and rugged unit for the small job. We find, however, that in many cases the limit of a shovel's performance is not the size of the bucket and the possible yardage, but the capacity of the trucks that are to be loaded. It is of little use to have a shovel of large capacity, capable of loading a five-ton truck in a minute, when loading conditions, length of haul or other factors keep the shovel idle a good part of the time.

"For that reason Wilfords are being used successfully on many big jobs, where their speed, mobility and economy are proving valuable."

Protection of Concrete from Alkali Water.—When concrete is to be used where it will come in contact with alkali water it is likely to deteriorate and lose strength unless protected. As a preservative the Bureau of Public Roads, United States Department of Agriculture, recommends as economical and effective four coatings of water-gas tar applied to the surface when dry at a rate of about ¼ gal. per square yard of surface, followed by one coating of coal tar. This provides adequate protection provided the concrete is of good quality, has been properly fabricated, and is not leaner than a 1: 2: 4 mix. In applying the water-gas tar it is necessary to allow time for the first coat to be absorbed before the second is applied. The last coating of coal tar should have from one to four days to dry before being allowed in contact with water.

Cities Own Billion Dollars Worth of Parks.—More than a billion dollars have been spent in the United States to acquire and equip municipal parks and a hundred million dollars are spent annually to maintain them, it is revealed by a two year study of city parks and forests completed by the Playground and Recration Association of America. Nearly 250,000 acres of parks and forests are reported by 1,681 municipalities. Practically all cities with more than 25,000 population have parks.

$2,000,000 Concrete Road Proposed in Mexico.—A concrete highway from Tiajuana to Ensenada, Mexico, is contemplated. The Governor of the Northern District of Lower California, Mexico, has asked approval of the Federal Government. The cost is estimated at $2,000,000. It is proposed to finance the construction on the basis of revenues receipts of the district.

Financial Statement Required for Texas Road Contractors.—The state highway department of Texas now requires that bidders on state and federal highway construction must file with the department a complete financial statement showing their financial conditions.

One Man Top Frames for MultiFoote Pavers

One man top frames which can be lowered or raised in less than ten minutes by one man using the hoisting power of the paver are recent improvements announced by The Foote Company, Inc., of Nunda, New York. The new top frames are said to be strictly one man affairs, and they replace the demountable superstructures first introduced by this company over 12 years ago. Greatly simplified means of using the power of the hoist—a feature originally applied by Foote engineers—makes it possible for one man to handle the top structure in avoiding overhead obstructions and costly delays.

There is nothing complicated about the improved one man top frames which are being used on the new 1928 machines. The operation of the quickly manipulated top frame is said to be extremely simple and easy. To eliminate the possibility of lost motion the number of parts has been reduced to a minimum, and each part is of the most rugged, modern design. These new top frames are the only ones on the market so constructed that one man alone can handle them.

All of the parts of this latest top frame are hinged and secured by removable locking pins. Without removing the water tank the height of the MultiFoote pavers can be reduced to 11 feet—the lowest of any paver now produced. But even this low height can be further reduced, for shipping by rail over lines having very low clearance heights, by removing the water tank.

In lowering the improved top frame all that is necessary is to secure the hoist cable in the clamp provided on the backbone, remove the connecting pin in the backbone, and lower the arch frame using the hoist brake. In raising the process is just reversed. The A boom frame is raised by utilizing the weight of the skip. Stretching a light chain between the skip cable and the top of the A frame, and lowering the skip lifts the frame up into position.

Several improvements have been included in the construction of the new top frames. One of these—a guide rod on the backbone—not only guides the frame into place but is also used to protect the frame by holding it rigid when going over rough ground with the top frame down. Every part of the one man top frames works so easily and freely that the manufacturer found by test that the achievement worked better and faster than expected. At first it was thought the simplified frame could be lowered in ten minutes by two men, but practical, working tests revealed that one man can do the work very easily in five or six minutes. Raising the frame takes a little longer, but one man working without undue haste can do it in much less than ten minutes. A complete series of hard tests are said to have shown this new top frame the fastest and most easily handled of any that have ever been produced.

Asphalt Technologists Hold Annual Meeting

The Association of Asphalt Paving Technologists held its annual meeting in the Old Colony Club rooms at the Hotel Statler, Cleveland, on the morning and afternoon of Thursday, Jan. 12, 1928, during the week of the road show.

The morning session, which was devoted to technical business and discussion, was called to order by the President, Hugh W. Skidmore, at 10:30 o'clock, and reports from the various technical committees were received and considered.

Because of recent difficulties experienced by some of the members, and further difficulties forseen, a special committee on asphalt paving cement was created, and the board of directors instructed to name the members thereof.

The afternoon session, which was devoted to the business of the association, was called to order by Mr. Skidmore at 2:15 o'clock; and, following the dispatch of routine business, the new officers were elected. Those at present holding office, members of the board of directors, and chairmen of main committees, are:

Honorary Member: Clifford Richardson, France. Past Presidents: Francis P. Smith, New York City; Hugh W. Skidmore, Chicago. President: Leroy M. Law, New Orleans. First Vice-President: Walter J. Emmons, Ann Arbor, Mich. Second Vice-President: Prevost Hubbard, New York City. Secretary-Treasurer: Charles A. Mullen, Montreal.

Main Committees: Present Practice, W. L. Hempelman, Chicago, chairman; Research Problems, Prevost Hubbard, New York City, chairman; Subgrade Problems, Roy M. Green, Lincoln, Neb., chairman; Professional Problems, Francis P. Smith, New York City, chairman.

The board of directors are the officers and the chairmen of the main committees.

Following the induction into office of the new President, Leroy M. Law, the time and place of the next annual meeting was discussed. It was the sense of those present that it would be most convenient to the members to have the annual meeting at the time and place of the Asphalt Conference, but the final decision was left to the board of directors.

Gasoline Tax Rates.—On Jan. 1. 1928, 33 states had a gasoline tax rate of 3 ct. per gallon or more. Of these states five had a rate of 5 ct., one a rate of 4½ ct., 12 a rate of 4 ct., one a rate of 3½ ct., and 14 a rate of 3 ct.

Southwest Road School and Show

Preparations are being made for the biggest and best road show and school ever held in the Southwest—the Third Annual Southwest Road Show and School—which will be held at Wichita, Kan., for four days beginning Feb. 21, 1928. This show, which started two years ago, has grown in popularity and now covers a territory of over fourteen states. An extensive federal government exhibit will comprise one section of the show and a number of state departments will have their own exhibits. In addition the manufacturers and distributors of machinery and equipment used in construction work, road building and maintenance of all types of roads, especially along the lines of motor and construction equipment and materials, will have at this show and school a large array of exhibits consisting of construction, road building, maintenance machinery, trucks, accessories, materials, etc.

The program as arranged will include participation by the following engineers and authorities upon roads and road building. First Day: Gov. Ben S. Paulen, "A State Road Program for Kansas;" John W. Gardiner, Director Kansas Highway Commission; "State System Progress."

Second Day: W. H. Lynch, District Engineer, Fifth District Bureau of Public Roads, Omaha, Nebraska, "Bureau of Public Roads;" Prof. T. E. Agg, Highway Engineer, Iowa State College, Ames, Iowa, "Economics of Grades and Surfaces;" Prof. O. L. Waller, Washington State College, Pullman, Wash., "Automobiles, Tire and Operation Cost;" R. L. Cochran, Nebraska State Engineer, Lincoln, Neb., "The Nebraska State Road Program."

Third Day: John Malang, Joplin Special Road District, "The Public and a State Highway System;" Prof. C. H. Scholer, Kansas State Agricultural College, Manhattan, Kansas, "Investigation on Concrete;" Charles M. Kerr, Field Engineer, American Wood Preservers Association, Chicago, "Wood Preservation;" R. O. McBurney, President, County Commissioners Association, Kingman, Kansas, "Counties and the State System;" Hugh Stephens, Vice Chairman, Missouri State Highway Commission, Jefferson City, Mo., "State and Federal Court Decisions;" Pyke Johnson, National Automobile Chamber of Commerce, Washington, D. C., "Regulation of Interstate Traffic."

Fourth Day: Prof. J. H. Kessnar, Department of Civil Engineering, University of Nebraska, "Bridges of the United States;" C. I. Felps, Construction Engineer, Kansas State Highway Department, "Kansas Road Construction Specifications."

Sheet Asphalt Pavements at Buffalo, N. Y.

A Paper Presented Dec. 1 at 6th Annual Asphalt Paving Conference

By GEORGE F. FISK

First Assistant Engineer, Department of Public Works, Buffalo, N. Y.

THE object of laying and repairing a pavement is to provide a satisfactory roadway for travel and the engineering problem is to provide one which shall cost the least amount per year.

Three items enter into this — the original cost, length of life and repair costs.

In the present problem we will only consider the cost of maintaining a pavement and how long we can make it last by proper repairs.

The price per yard for repairs is an entirely indefinite unit by which to measure work. The only measure of value of repairs is in what it costs to maintain a pavement over a term of years and how long the pavement lasts.

Buffalo's First Sheet Asphalt Laid in 1878.—Buffalo has had 49 years experience with the laying and maintenance of sheet asphalt pavement. The first sheet asphalt pavement in this city was laid in 1878, and there has been more or less of this class of pavement laid every year since.

The total amount of sheet asphalt pavement laid up to Jan. 1st, 1926, is 8,445,789 sq. yd., at a total original cost of $26,624,451.48. Of this total amount of pavement laid there is now in existence 1,230,204 sq. yd. which were laid prior to 1897 and 2,100,720 sq. yd. which were laid prior to 1907.

A large amount, 2,700,000 sq. yd., was laid in the years 1889 to 1894, during the real estate boom, which forced improvements some years in advance of real requirements.

Of the total amount of square yards laid, 6,066,121 have been released from guaranty and 2,379,648 sq. yd. are still under guaranty.

In all 2,307,847 sq. yd. of the asphalt pavement laid since 1878 have been taken up and replaced. The causes of removal are: deterioration, requiring repaving; taken over by the street railway company when tracks were laid in the street; by grade crossing elimination work, etc.

Most of this pavement was laid on a 6 in. concrete base. Natural cement was used up to 1903, since which time Portland cement concrete has been used. On account of traffic conditions it was considered advisable to increase the thickness of the base from six (6) to eight (8) inches, and since January 1926, eight (8) inch Portland cement concrete base has been used under all streets, and on streets carrying extremely heavy traffic we have used a base 9 or 10 in. thick. In a few cases where the original pavement was of first class macadam with a Telford base we have used this base as a foundation for the new asphalt surface.

Specifications for Old Bituminous Base.—Approximately 30,000 sq. yd. of pavement, having a bituminous base, was laid during the years 1878 and 1881 and this base has since been resurfaced in some cases, the base having outlived two wearing surfaces and in all cases the base still having a further life, the duration of which cannot be determined.

The specifications, under which this base was laid, taken from a contract dated April 24, 1878, for paving Delaware Ave. between Virginia and North Sts. are as follows:

"The space between the curb stones must be paved with the Asphalt pavement in the following manner:

After the excavation is made the foundation is to be thoroughly rolled with a ten (10) ton roller. The stone for first course to be of proper size of lime or sandstone, to be eight (8) inches in depth after being thoroughly rolled, and laid in courses of not more than three (3) inches, each course being rolled as the first. The surface of the broken stone then to be covered with hot bitumen. On this to be placed a binder course not less than three (3) inches in thickness when rolled. This course to be the same as the wearing layer, being composed of clean sharp river or bank sand mixed with proper proportion of asphalt and laid while at a heat of not less than 300 degrees Fahrenheit and rolled while hot, first with a steam roller weighing five (5) tons and afterwards with a steam roller weight ten (10) tons. On this last mentioned course will be placed a layer not less than two (2) inches thick when rolled, the mixture being composed of clean sharp river or bank sand mixed with proper proportions of Asphalt and laid while at a heat not less than 300° F. and rolled with steam roller same as the previous layer. The steam rollers to be heated while in use. The surface to be finished with a coating of portland hydraulic cement swept in during the process of rolling.

At one time we laid a considerable amount of sheet asphalt over the common Medina stone pavement on a sand base. This proved satisfactory for a time on light traffic streets, but as the traffic increased we found this method of construction was not entirely satisfactory and have discontinued such method.

Grades and Underdrainage. — Much of this pavement is laid on flat grades, nearly one-half on a grade of 0.33 per cent to 0.40 per cent. We have seldom laid sheet asphalt on grades exceeding 3 per cent.

Since 1891 under-drainage has been cared for by the construction of a drain tile underneath curbs. This class of construction has been generally used except on a macadam base or where natural drainage was exceptionally good. Surface drainage is cared for by the construction of sewer inlets, approximately 400 ft. apart, on each side of the street.

Binder and Top Course.—Most of the early sheet asphalt pavements were laid with a ½-in. cushion coat, up to 1892, since which time 1½ in. of open binder has been used. The top course has usually been 2 in. in thickness. There are a few exceptions, in some streets laid under private contract where the street has been paved prior to the deeding of same to the city.

Up to 1892 sheet asphalt pavements were laid under specifications furnished and filed by the various paving companies as to wearing surface. Since that year they have been laid under open city specifications allowing the use of any suitable material.

Most of the pavements were of fine sand mix, but in later years some pavements have been laid using a stone mix; in some cases 25 per cent of ⅜ in. or less flint limestone screenings have been used.

Pavement Guaranty and Repairs.—Pavements were generally laid under a 5-year guaranty until 1898, but a few had a 6 or 8 year guaranty. Since 1898 all pavements have been laid under a 10 year guaranty.

During this guaranty period, whenever any section of pavement disintegrates or shows waves in the surface, the asphalt and binder are cut out, in rectangular shape, to the base, and repaired with new asphalt and binder, in accordance with the original specifications. All settlements of the surface of pavements holding water and other settlements showing a variation in elevation of ⅜ in. or more from the edge of a 4 ft. straight edge, are brought to conform to the true crown of the grade of the pavement. If it is found necessary in any 300 lin. ft. of pavement to repair more than one-third of its area, exclusive of the pavement between the rails of the street railway or if the lineal feet of cracks in any section of pavement exceeds the proportion of 1 lin. ft. cracks to 4 sq. ft. of pavement, then the entire wearing coat in such defective section is cut out to the base, and new asphalt and binder laid in accordance with the original specifications.

All cracks ⅜ in. or more in width are considered disintegrations.

If in the last year of maintenance it is found that more than one-half the total area laid under any one contract has been repaired (excepting cuts made for underground work), then the contractor is required to cut out to the base all the asphalt and binder laid

under that contract and lay new asphalt and binder.

Repairs Under City Supervision.—After the period of maintenance under guaranty has expired, the streets are taken over and repairs are made under city supervision. All of these repairs have been made under contract.

The average depth of binder used in repairs is 1½ in. and the average depth of top is 1.57 in.

The repair contract provides a price per ton for asphalt surface mixture, measured loose at the plant and delivered on the street, a price per ton for open binder, same conditions, and a price per gallon for A. C. hot on the street, ready for paving. The contract also provides a price per square yard for all street labor, which includes chopping, cleaning and the laying of new material. There is in addition a price per square yard for replacing cuts in trench work and other minor items. The contract also carries a guaranty for one year.

During the period of maintenance, under the repair contract, patches showing depressions exceeding ¼ in., nodule places, cracks or open joints or any signs of disintegration are replaced and area computed at the end of the working season and the price charged to the contractor against the guaranty.

Where it is necessary to make a joint in a guaranty patch on account of a contiguous repair to the pavement, an allowance of 6 in. in width is made and not charged to the guaranty.

During the period of this guaranty the city, in making subsequent repairs, marks out and replaces such area as is deemed necessary for proper maintenance of the pavement. 60 per cent of such area laid under such contract and so removed outside of the 6 in. in width mentioned above is deemed to be defective in computing the total area of this overlap.

The contractor having the guaranty for maintenance under previous contract and the contractor having a similar guaranty under current contract is permitted to work out the area as mentioned above, at such times and in such streets as the city engineer directs. In the event of the contractors not availing themselves of these privileges they reimburse the city at the average price per square yard, based on the cost of making such repairs during their period of maintenance.

Considerations Governing Repairs.—In making repairs, when appropriations warrant, the following considerations govern: A hole left as such for a time grows rapidly with traffic. If the pavements be old and hard, the impact against the far edge of the hole rapidly crumbles the adjoining material.

If the pavement be in a more plastic condition, the dropping of wheels into such depression thins out the top around the near edge, requiring a large cut back to reach a reasonable thickness for a repair joint. On the far side of the hole the wheel impact shifts the material forward, forming a ridge, and wheels dropping into this ridge form a depression beyond, which in time produces another and smaller ridge. This action continued produces a series of ridges and depressions or waviness, which must be removed for proper repairs. Similarly, any ridge or depression tends to extend the wavy condition and is undesirable. These considerations have led to the policy of preventing rather than filling holes. In marking for repairs the intent is to remove any surface which is in such a condition as to produce a hole before the probable date of the next repair and to remove troublesome ridges or depressions. While not possible to entirely accomplish the desired result, yet the results obtained fully warrant the continuance of the policy.

The removal of surfaces showing indications of early failure, but in an apparent serviceable condition to the casual observer has led to some criticism of unnecessary repairs, but it has also eliminated the old complaint of failure of repairs where they were not carried back far enough to reach sound material for a joint.

Two markers are steadily employed to indicate all repairs to be made, who by long experience have a personal acquaintance with their work and can follow it from year to year. They are followed by locaters who locate and measure each area marked, the contractor furnishing one on each tape for his check on measurements. These men are employed during the winter season in plotting all areas repaired and in determining the "overlap" covered in previous contracts.

Cost of Maintenance.—During the year ending December 31, 1926, we maintained 3,315,555 sq. yd. of sheet asphalt pavement at a cost of $0.1240 per square yard. The cost per ton for asphalt was $8.10 and for binder $6.70, weighed at the contractor's plant and delivered on the street. The labor cost per square yard on yards repaired was 95 cts., which includes the marking out of the repair and cutting out the same to the base; the removal from the street of all old material; the painting of joints; the placing and rolling of new material and cleaning up after the repair is complete.

The cost of asphalt repairs from 1889 to December, 1925, taken from our record in 10 year periods is as follows:

Year	Yards Maintained	Cost per Sq. Yd.
1885 to 1889	28,445	$0.0159
1899	1,749,131	0.0466
1909	1,885,478	0.1101
1919	2,424,426	0.1113
1925	2,553,414	0.1583

The average cost of repairs on sheet asphalt maintained is $0.0613 cts. per square yard for 88,634,812 yd. years of maintenance.

Average Age of Sheet Asphalt Pavement.—The average life or age of sheet asphalt pavements out of guaranty laid in Buffalo between the years 1878 and 1915 and without street railway tracks is 24.39 years. The average age of asphalt pavements without street railway tracks replaced from 1892 to 1925 is 24.97 years. The average age of pavement replaced 1921 to 1925 is 31.71 years.

Average age of asphalt pavement maintained is 22.95 years.

Cost of Repairs to Pavements on Bituminous Base.—It may be interesting to note the repair costs on those pavements laid on bituminous base, of which I have previously spoken, although the yardage is not great.

During 1878, 9,286 sq. yd. of pavement was laid on a bituminous base. For some reason which I am not able to determine, this base was re-surfaced with asphalt in 1892, the repair costs from 1878 to 1892 being $0.0554 per square yard. This base was again resurfaced in 1925, repair costs from 1892 to 1925 being $1.4435 per square yard. 3,755 sq. yd. laid in 1880 were resurfaced in 1913, repair costs between 1880 and 1913 being $0.7925 per square yard. The repair costs from 1913 to date on this piece of pavement is $0.1620 per square yard.

7,160 sq. yd. laid in 1880 were resurfaced in 1909, the cost of repairs between these dates being $0.8754 per square yard. The maintenance cost between 1909 and 1926 being $0.2319 per square yard.

8,876 sq. yd. of pavement laid on a bituminous base in 1881 were re-surfaced in 1924, the repair costs between these dates being $1.7743 per square yard.

Maintenance Records.—Our maintenance record begins the day the pavement is released from guaranty and from that time until the street is repaved we keep an accurate cost of repairs, as well as the location of same. These records are invaluable as they are used in determining the economic life of the pavement and we are able at any time to analyze the cost of repairs to date.

The real objective in laying and maintaining a pavement is to obtain the greatest usefulness from the given expenditures. This is a matter requiring careful engineering analysis, and any hasty conclusions based on partial information or consideration are misleading.

We have been most conservative in construction and maintenance of our pavements, requiring and securing the best in construction and making thorough maintenance repairs.

Few other cities have such complete records as Buffalo and hence it is difficult to obtain accurate comparative figures of average life, but many cities assume such at 15 to 18 years with nothing accurate on which to base such assumption.

Of two cities similarly situated in all ways, one publishes in detail its costs and the other publishes no complete

cost records, but simply makes a statement that asphalt repairs cost a certain amount.

When such figures are published pretending to show the cost of repair work those not familiar with the methods of repair are mislead as to real costs.

Buffalo was next after Washington, D. C., the first city to have a large amount of asphalt. It was, therefore, obliged to study the repair problem at an early date and by its long experience has so standardized the form of contract and methods of repair as to insure satisfactory results.

A most thorough search has been made for real and reliable information, figures which could be accepted as showing the actual full expense of making asphalt repairs. In making such search I have visited many of our large cities from Boston, Mass., to St. Louis, Mo., and from St. Paul, Minn., to New Orleans, La. In one city visited it was said in substance: "Of course it costs more than reported. This is a year term of office. A price has been set which we must maintain. We are not going to make liars out of our predecessors. It is not right, but we have to do it."

In another city when the old material is torn up for repaving, the cost of carting this old material to the asphalt plant is included in the cost of repaving the street instead of repairs. Then this old material is warmed over by the plant, a small amount of A. C. being added to the mix. I said to the operator of the plant, "How much A. C. do you add to this mix and when do you made such addition?" The answer came back "Oh, we add a little once in a while when we think of it." Then this material is carted to the street by the municipal carting division of the city and such cost does not appear in the repair costs.

Another city includes in the asphalt repair costs not only the cost of repairing sheet asphalt, but all pavements of a bituminous mix.

One other example, a certain city gives out its repair costs, but the area of each patch is computed using the two maximum diameters of the patch regardless of area repaired.

In several cities however, full honest endeavor is made to show actual costs and the results of the analysis of such records are our only safe guide.

Gillette Formula Used in Determining Economic Life.—In our budget we have three distinct accounts for street construction, namely; new construction, replacement and maintenance. We are not now considering new construction, but we are interested in maintenance and replacements. In determining the economic life of pavements we use the following formula given by H. P. Gillette in his cost data: "The average first cost plus the average annual repair cost must be a minimum." Or in other words, the first cost, plus the total repairs, divided by the age of the pavement must be a minimum. For example, we are this year repaving a street (Doat Street), the repairs to which this year would have amounted to approximately 20 cts. per square yard. The determination to repave was made as follows:

Assuming the original cost of the top to be $1.50 per square yard we found our total repair cost since the street was paved in 1902 amounted to $1.65 per square yard, or a total original cost plus repairs of $3.15, divided by the number of years service of the pavements (25) would allow a repair cost of only 12.6 cts. This rule however, cannot be applied indiscriminately, but must be used with engineering judgment. There are cases where the pavement is nearing its economic life and we find that certain localized causes have necessitated extensive repairs, while the remainder is in comparatively good shape, in such cases it is possible that an expense much exceeding the theoretical expense may place the pavement in a condition where its economic life may be prolonged. The rule must be applied in conjunction with knowledge of local conditions and charter requirements. The charter of the city of Buffalo contains an excellent provision which is of great assistance in meeting this condition, and it may be safely recommended for use in other cities where the charter or local ordinances make no provision for the meeting of such situation. This provision is as follows:

"All repairs of accepted streets shall be paid for from the general Fund.

All streets or part of streets paved at the time this act takes effect, or which shall subsequently be paved, shall be deemed accepted streets within the meaning of this title, and shall be repaired when necessary, if the Superintendent of Public Works certifies that less than one-third of the carriageway is in condition requiring repairs, but whenever the Superintendent shall certify that it is not expedient to make further repairs upon that pavement, in an accepted street or in the portion thereof between two streets that intersect or meet the same, the council may order said street, or portion thereof mentioned in such certificate, repaved, and two-thirds of the expenses thereof shall be paid by local assessment and the remaining one-third thereof shall be a charge on, and paid out of, the general fund of the city, as provided in this act.

One of the greatest benefits resulting from our records is the fact that we are able at a moment's notice to determine the total cost of repairs to any pavement. This has a very appreciable effect on the property holder who is against having his street repaved. When we show him the total cost of repairs compared with the cost of original pavement and show him why repavement is needed he usually goes away satisfied.

Road Construction in Nova Scotia.—During 1927 over 581 miles of road were graded in Nova Scotia, of which 342 miles were surfaced. Owing to adverse weather conditions, only two-thirds of the grading program was completed.

Methods for Good Pedestrian Control

Three requirements essential to the success of regulations designed to control jay walking and prevent the congestion and danger arising from the conflict between pedestrians and vehicles at intersections are outlined in a recent report by the Albert Russel Erskine Bureau for Street Traffic Research.

"Primarily the regulations must appeal to the public as being reasonable," states the report, prepared by Miller McClintock, director of the Bureau, which is endowed in Harvard University by The Studebaker Corporation. "Pedestrians will willingly wait at an intersection for their turn to cross if, while they are waiting, traffic across their path is comparatively heavy and regular, at least sufficiently so to make crossings at the time appear to be difficult.

"When pedestrians are forced to wait at intersections during periods when there is no traffic to interfere with their immediate crossing the entire system of regulation appears unreasonble. For the success of pedestrian control it is therefore necessary that traffic should be heavy, and that the flow of vehicles should be reasonbly constant during the pedestrians' stop interval. This is naturally accomplished by keeping the stop and go intervals as short as possible—a requirement for good vehicular control as well as for pedestrian regulation. One of the chief faults at the present time of both automatic signal control and control by traffic police is the tendency to hold traffic for intervals that are unnecessarily long.

"In the second place, provision must be made for all pedestrians to reach the sidewalk before cross traffic begins. When vehicle traffic is released without adequate warning pedestrians who have been obeying the signals will often be caught in mid-street. Naturally, this leads to a disregard of regulations which place restrictions on pedestrian movement without offering the pedestrian an equivalent value in definite protection. Proper manipulation of the neutral interval will make it possible for all pedestrians to reach the sidewalk before vehicle traffic is released.

"Finally, pedestrian control is a type of regulation which must be accepted voluntarily by the public. It is seldom successful when forced on by police power. To this end it is important that the traffic police should be thoroughly instructed in their duties before the system is put into effect, and it is likewise desirable that the public be carefully educated by a suitable campaign of publicity before pedestrian control is attempted."

Chart of Elements Affecting Concrete Construction

From the Manual of Instructions of the California Division of Highways

CHART A gives the compressive strengths of sand mortars of various proportions. The strengths are given in percentages of compressive strength of neat cement. A cement having a compressive strength, neat, of 12,000 lb. per sq. in. at 28 days is assumed as 100 per cent and all values given are prorated on the basis of the use of this cement in the varying proportions required.

Chart B shows compressive strength of concrete with varying cement content. The compressive strength is shown in pounds per square inch based on first-class aggregate, and the cement testing neat at 12,000 lb. per sq. in. at 28 days. The concrete is assumed to have a ½ to 1 in. slump, the water varying slightly as required by its aggregate.

Chart C shows the effect of voids in course aggregate on compressive strength. The graph is particularly valuable and is shown both in percentages and in pounds per square inch. The effect of excess voids in the course aggregate is, of course, to require the addition of more sand to maintain workability with a corresponding decrease in compressive strength of the concrete.

Chart D shows effect of water on compressive strength and is founded on tests in our own laboratory, on tests in Bulletin No. 58 of the Bureau of Standards, and on tests by Prof. Abrams.

Chart E shows increase in compressive strength with increased time of curing. The values shown will vary more with conditions than those given in other tables. In this instance the values are based on mean temperatures of 70° or higher. Lower temperatures will retard curing time.

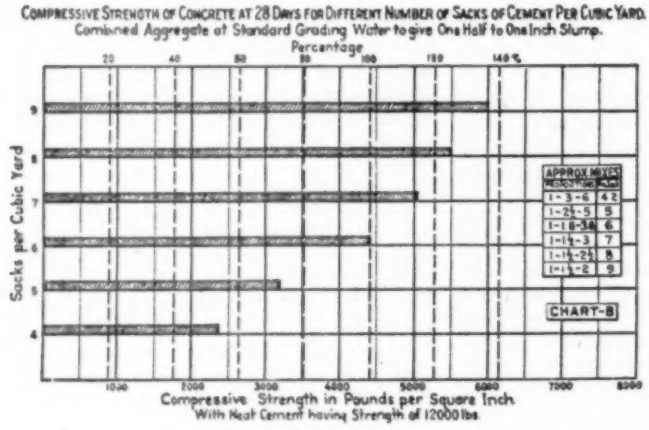


Chart B

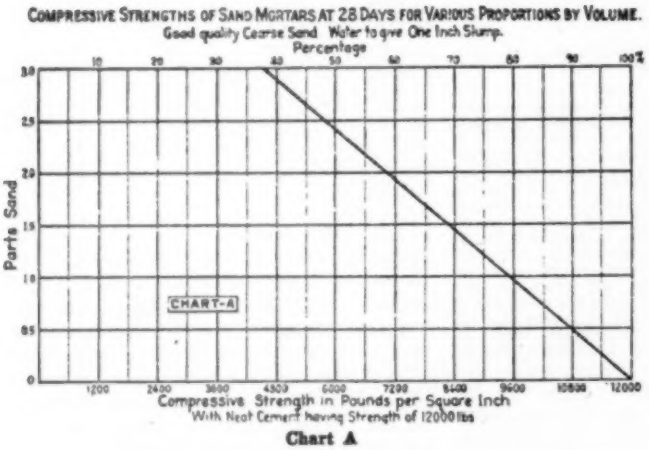


Chart A

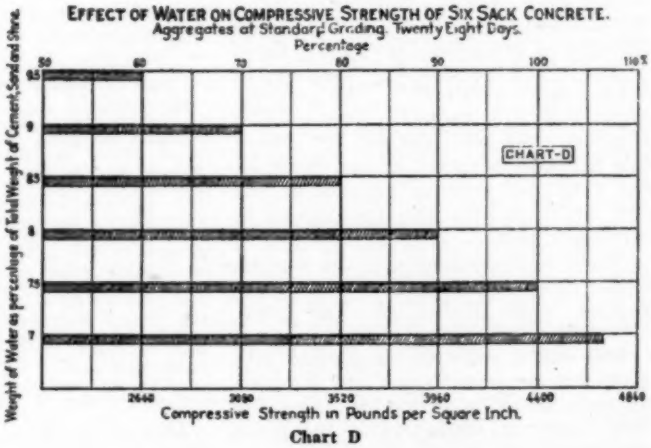


Chart D

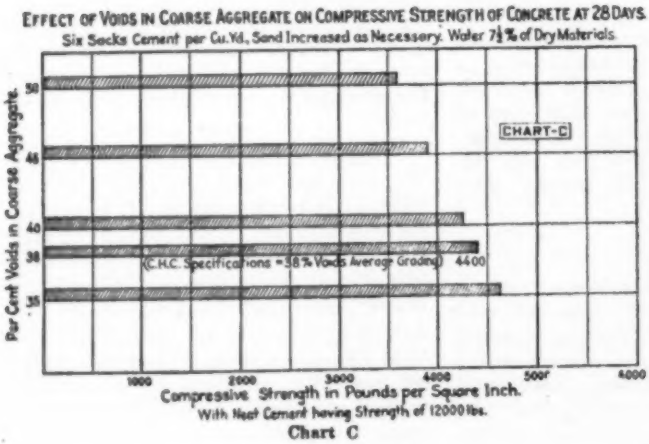


Chart C

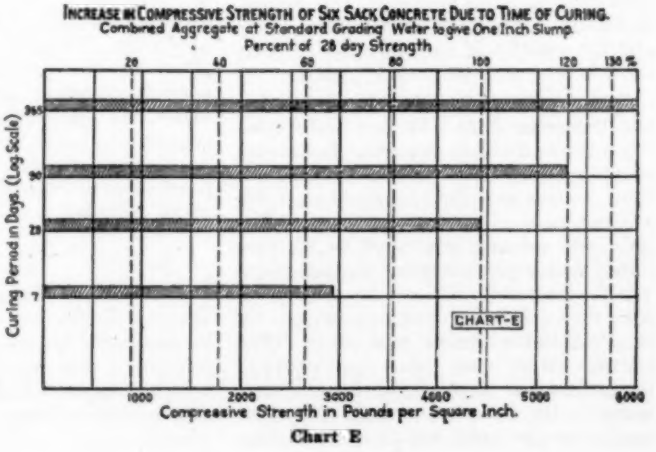


Chart E

Fundamental Features of Gravel Road Construction in Washington

Discussed in Paper Presented at Convention of British Columbia Good Roads League

By E. R. HOFFMAN

Formerly Construction Engineer, Washington State Highway Department

IT is essential to realize first of all that each section of highway to be improved with a gravel surface presents a distinctive problem. For a long time public officers responsible for the design and construction of highways attempted to build all roads to the same pattern by and through the means of a definite specification. In recent years, however, engineers have recognized that each section of road to be surfaced presents special features that must be taken into consideration if the construction and maintenance are to be successful and economical.

The following discussion is intended to point out fundamental features only with the thought that the local aspects of each proposed improvement will be given consideration in the plan of construction.

Use of Crushed Gravel.—Generally as road development came about in this western country, gravel, where available, was used for surfacing and crushed rock was used where gravel could not be obtained. It is now recognized that crushed material, either gravel or rock, is far superior to the ordinary gravel of glacial or stream deposit. The practice of crushing the gravel and screening to remove oversized particles is now quite general and strikingly effective in producing good results.

For a time the opinion was held in the State of Washington that the expense of crushing gravel would not be justified by the results. Possibly this opinion was well taken some years ago before the development of modern equipment. At present there is little if any difference in the cost of crushed gravel or screened gravel for the average improvement.

Following is a statement of the actual cost of preparing material for maintenance purposes on four projects using state-owned equipment and state employees. These figures cover the cost of preparing the material and placing it in the trucks, but do not cover the cost of hauling and spreading on the road.

Ashford—Screened gravel, 80c per cu. yd.

LaGrande—Crushed and screened gravel,.51c per cu. yd.

Elbe—Crushed rock, 92c per cu. yd.

Divide—Crushed rock, 63c per cu yd.

The cost of screened gravel at Ashford was high for the reason that a large amount of oversize gravel was encountered which had to be disposed of by hauling and dumping in waste piles.

As a rule the crushing and hauling of maintenance gravel for the State of Washington is performed under contract. There are a number of contractors who have first-class equipment for this purpose, and as a result the contract prices are quite reasonable. In Western Washington the average prices range from $1.05 to $1.40 per cu. yd. on the road with an average haul of approximately 2 miles.

Features to Be Considered for Construction Details.—Following are eight outstanding features to be considered in determining the details of construction:

1. Volume and kind of traffic; 2. Width of surface metal; 3. Character of subsoil; 4. Climate; 5. Drainage; 6. Materials available for surface construction; 7. Thickness of surface metal; 8. Special features of the particular improvement.

A discussion of each of these eight features will not be attempted here. Road construction is no longer guesswork for any layman to attempt if the best results are to be obtained. If the public is to be given a good road for the least expenditure a thorough study by competent engineers is essential.

The surface on which the gravel or crushed rock is to be placed should be true to grade and cross-section. It is difficult to construct a first-class surface if the metal is placed on a rough grade; moreover, part of the surfacing material is wasted. Rock and gravel exceeding 2 in. in diameter should be removed from the full width of the roadway before the placing of surface metal is started. If the grade is made of rock or coarse gravel, a covering of fine material such as sand, sandy loam, small gravel or other material should be placed. If large rock are left uncovered on the grade or on the outer edges of the grade, they will become a nuisance during maintenance of the highway.

It is impractical to write a specification for the hardness of gravel or rock to be used for surfacing. A gravel may be a decided success in one locality and a failure in another, due to difference in climatic conditions, subsoil, character of traffic or some other cause. The acceptance or rejection of a material is dependent upon an understanding of the entire situation.

Best Results from 2-Course Gravel.—The best results are obtained by placing the gravel in two courses of approximately equal thickness. As a measure of economy the lower course can be and usually is constructed of larger material than the top course. The practice in recent years required that the gravel for the base course should pass a 1½-in. ring and the gravel for the top course should pass a 1-in. ring, and in either case should be well graded from the maximum size to dust. The engineers for the United States Bureau of Public Roads are very much in favor of gravel passing a ¾-in. ring.

The finer materials give a superior riding surface that is much simpler to maintain than a surface constructed of coarse material. It is advantageous to haul over the surfacing metal as it is placed in order to get the benefit of the rolling action of the truck wheels. The grade and each course of metal should be kept smooth during construction as well as afterward. This point cannot be stressed too much.

Use of Clay Binder.—The gravel will not stay in place unless it is bound with some sort of material. Recently the tendency has been toward the use of a water resistant clay for this purpose. The test for satisfactory clay to be used as a binding agent as practiced by the State of Oregon and later by the State of Washington is accomplished by forming a ball of the material approximately 1 in. in diameter, using sufficient water to give a plastic and easily moulded mixture. The ball is dried at normal temperature and then suspended in water on a ½-in. screen. The time required for the clay ball to dissolve and fall through the screen is a measure of its quality. Fifteen minutes is about the minimum accepted. Some clays will resist the water for several hours and an occasional sample will stand up for a day or more.

A small amount of clay is mixed with the gravel on the road as a cementing agent. If an excessive amount is used, the surface will become hard and difficult to maintain in dry weather and rather soft in prolonged wet weather. The percentage of clay added by volume of the gravel varies from four or five to twelve or fifteen, depending upon the character of the gravel, the amount of natural binder

in the material and climatic conditions.

Gravel Road Maintenance.—The maintenance of a gravel road can be attempted by so many methods and some sort of result accomplished by each that it is difficult to determine which is the proper course to adopt. Climatic conditions, drainage, character of subsoil, amount and kind of traffic, width of road, equipment and funds available for maintenance, and character of gravel available for repair have a bearing on the quality of maintenance possible and on the method that will produce the best results.

A gravel road has been maintained in good condition in the State of Washington under an average traffic of 3,000 cars per day during the summer months; there was, however, complaint on account of the dust and the cost was rather high. It appears that a more expensive type of surface is justified when the average traffic reaches 1,000 or 1,200 cars per day. Maintenance costs mount rapidly when the traffic exceeds this amount, and also the traveler finds the dust rather bad during the summer months.

The principle of continuous maintenance is sound. The old practice—not altogether abandoned at this time—of working on the roads when there was nothing else to do is wrong economically as regards the public funds for road purposes and also from the viewpoint of economical transportation. Poorly maintained roads are a tax on those who use the roads.

Maintenance forces should be organized for such continued effort as may be necessary to keep the roads in repair at all times.

Keeping the Surface Smooth.—The most important and most difficult part of road work is keeping the surface smooth. Dragging with this end in view should start before and continue during the placing of the metal and the surface should not be permitted to become rough. It is cheaper to keep a surface smooth than to repair a surface that has been permitted to become rough.

A float or drag from 20 to 30 ft. in length and 5 or 6 ft. wide with two or three iron cutting edges placed at an angle of 30 degrees near the center is very effective while the road is soft. Floats of this character may also be used with good effect as long as the surface is smooth. Should the surface become rough, only heavy equipment will be effective.

In ordinary maintenance and in cuting the surface with heavy equipment the metal should not be cut too deeply as an excessive amount of loose gravel results and the binding material will be lost as dust.

Where the width of the roadway will permit, the grading or smoothing operation should be conducted so as to carry the loose material from one side of the road to the other, thereby leaving a windrow of loose gravel at the edge of the road. Carrying the loose material from one side of the road to the other leaves the excess loose gravel at the side of the road out of the line of traffic; it also has a tendency to keep the crown flat, thus securing better distribution of the traffic, while grading from both sides toward the center tends to build the center too high.

Maintenance should be carried on throughout the year. Dry weather grading or smoothing of the gravel can be very effective if supplemented by the addition of small amounts of fine gravel where needed. The frequency of blading or smoothing of the surface depends upon the traffic, the width of roadway and the climatic conditions. On the heaviest traveled roads, the surface will need to be smoothed out every day while once a fortnight may be sufficient where the traffic is light.

The State of Washington uses several types of equipment, each apparently well adapted to perform certain parts of the work.

For cutting and re-shaping an old gravel surface, heavy equipment is essential and is generally a 10-ton Caterpillar tractor and a 4-ton grader. In some localities this work is accomplished with a 2-ton grader drawn by a heavy truck.

For heavily traveled roads where frequent blading is necessary motorized graders of the one-man control type are effective and economical. This equipment is satisfactory on narrow roads where the traffic is light.

Practically all grader equipment used by the State of Washington is mounted on rubber tires. The life of the grader is prolonged and the work is more attractive to labor.

Importance of Trained Personnel.—But few people realize the importance of trained personnel in highway maintenance. The thought is that any laborer can do the work effectively. This opinion has led to a waste of funds and poor roads. The men on the grader would be encouraged to plan his work to study the effectiveness of his methods. The person having general supervision of the work should be competent to avoid schemes that can only result in failure or partial success and he should have ability in selecting men to do the work.

There is an unusual opportunity in the maintenance of roads for the development of new methods and no doubt the next few years will see many changes in maintenance methods.

Changes in Highway Officials.—At the annual meeting of the American Association of State Highway Officials last October, W. C. Markham, executive secretary of the Association, reported that in the year 21 states had made changes in the officiary of their highway departments involving a change in the chairmanship of the commission or of its chief engineer, or both. Ten states changed both heads of commissions and chief engineers.

Use of Tamper Roller for Compacting Gravel

Extract From Discussion at Canadian Good Roads Association

By O. E. HESS
Engineer, Kent County, Michigan

In the construction of our gravel roads we differ somewhat from the state work in northern Michigan, due to the fact that we build only one type of gravel road, the surface of which is 16 ft. wide. The gravel surface is all put on in one course of about 7½ in. in depth, loosely. That compacts to 6 in. We specify a 6-in. compacted surface. All the material is under an inch in size. It must pass through a screen having a 1-in. circular opening. Of course we use the square-mesh screens as well. We specify that not less than 60 per cent nor more than 85 per cent of the material shall lodge on ⅛ in. We have from 15 per cent to 40 per cent of binder smaller than ⅛ in. We find that material with less than 15 per cent of sand is very hard to compact and does not make any better roads. It makes what you might call a poorer gravel. We do not use it for economic reasons, but because it is easier to get a good road. The gravel is laid with a tamper roller, and when we accept the road from the contractor it is smooth and hard, and looks very much the same as a steam-rolled road after it has been maintained for a year or so.

These tamper rollers have been a great aid to us. A few years ago we used to put on the gravel and let the traffic compact it, and sometimes it took three or four years to do that, and that was very disagreeable for the traveling public. Now the roads are packed right down from the beginning. This roller is cylindrical and the drum is made up of sections of cast iron, and it looks like a cylinder 8 or 10 ft. long, and 3 ft. in diameter, with a surface that looks somewhat the same as the appearance of the grid of a catch basin.

We use screened gravel in some specifications for both maintenance and construction, and that gravel may contain crushed material. We specify a certain size and all of it must be less than 1 in. in size, and that is as far as you need go. We have a great many different kinds of gravel in the county, and no matter whether sand gravel or clay gravel, our specification will give us a gravel that is satisfactory, and there is no necessity of going into a lot of detail respecting the grading of material.

Vermont Votes $8,000,000 for Repairing Flood Damages.—At a special session of the Vermont Legislature last month a bond issue of $8,000,000 was voted to repair damages caused by the December flood. This money for the most part will be expended on highways and bridges.

Cleveland Road Show and Convention Again Breaks All Records

Continued Development Demonstrated In Both Equipment and Paving Methods

PERHAPS it was a good thing that the annual convention of the American Road Builders' Association and the Road Show were held in Cleveland this year, for it showed that this great annual affair can continue to expand and to break all records year after year regardless of the meeting place. It demonstrated that the convention and show has great merit in itself, since only worth while things show continued growth and development. While it might otherwise have be said that the growth was due to the meeting place and not to the meeting, the selection of Cleveland for the year meeting cast all such considerations out of the picture. It is now assured that the meeting next year will again break all previous records no matter what leading city is selected for that meeting.

There must be a real reason for the steady and phenominal growth of this convention and show. Records are not broken year after year without cause. This reason can only be discovered by actual attendance each year. Here it is.

The convention is a good drawing card each year because of the unfailing excellance of the programs that are arranged, and because of the fact that the art of paving has been advancing with such leaps and bounds that everyone finds it necessary to attend each year in order to get first hand the latest ideas and methods advanced by those engineers and contractors who are responsible for the various developments. The great economic value of each years' new developments makes it highly necessary for each engineer and each contractor to obtain the information there available by attending each year. The resulting application of new methods each year has been the primary cause for the growing excellence of the nations' highways.

Show Well Attended.—The Road Show itself is always well attended, partly because everyone is already in town for the convention and more because of the fact that manufacturers are constantly improving materials and equipment to the end that roads may be built better, quicker, and cheaper. Increased productivity, lowered costs, better workmanship, all interest the contractor and the engineer. Since this show is the annual meeting ground for these equipment users and the equipment manufacturers, where buyer and seller may meet on common ground and examine the improved equipment of the year, it results in a condition that immerdiately results in greater attendance and greater equipment sales.

Here, then, are the evident basic reasons for the continued growth of both convention and show from year to year.

The following news of the convention and of the show will demonstrate these points.

The Convention.—The convention itself got under way on Tuesday, Jan. 10, and held interest to the very end. This day, known as Governors' Day, began with a morning session in the Grand Ballroom of the Hollenden Hotel, where President Babcock presided. After the invocation, and welcoming addresses by Gov. Donahey and Mayor Marshall, and the response by President Babcock, an address was made by Mr. James H. MacDonald, treasurer and honorary chairman. This was followed by the presentation of an emblem to President Chas. M. Babcock, then the presentation of emblems to past presidents of the Association. Chas. M. Upham then presented his report on Highway Safety. He reported a very successful safety campaign that included the distribution of safety literature, and the cooperation of the churches, the schools, and the newspapers, through which a great number of adults and children were reached with the safety messages of the association, and many persons were enrolled. The session was closed with a further report on the practical application of highway safety by J. H. Brown, editor and manager, Motor Touring and Camping.

Construction Sessions.—While general sessions were held in the mornings throughout the convention, each session devoted to some particular idea such as the Pan-American session on Wednesday, the afternoons were given to separate sessions for contractors and for engineers. In this way a great many subjects could be discussed in the limited time available, and individuals could attend only those sessions that interested them. The contractors' sessions dealt with evil practices and conditions that affected the contractors in their work throughout the country and to the costs of doing work. Especial attention was given to work involving rural roads, where faulty bonding laws, and other conditions have made it quite difficult for many contractors to remain in business, and where contracts are defaulted and profits lost because of conditions that in places are said to be intolerable. Equipment dealers came in for some criticism on the grounds of their methods of doing business, but for the most part the serious conditions were laid to laws now in force in many states and counties.

Abolish Lien Laws.—For instance, there was the paper read by A. R. Hirst, Chief Engineer, Vibrolithic Corporation of America, wherein he recommended the elimination of all lien laws protecting sellers of machinery, materials and supplies, severe penalties for construction delays and bonuses for time saved, the compelling of bonding companies to refuse the bonding of irresponsible contractors, the elimination of bid bonds and certified checks not backed by the contractors' own cash, and the boycotting of all factors in the paving industry who encourage bidding by the inexperienced and incompetent contractor.

Cash Needed.—W. F. Creighton, president, Foster & Creighton, general contractors, Nashville, Tenn., covered part of the same ground when he presented a paper showing how much cash and otherwise liquid assets are needed by a contractor to carry a paving job through to satisfactory and profitable conclusion. In the course of this paper he cited records taken from a seven mile job recently completed by his company. He also claimed that a contractor should prepare his own estimates based upon quantities computed by himself before entering any bid, since such an estimate, if carefully prepared, would usually show costs higher than would otherwise have been allowed for in the bid.

Credit.—Allen J. Parrish, president Illinois Association of Highway and Municipal Contractors, hit at the practice of many material and equipment firms of granting extended credit to the contractor, and exacting payment only on or after completion of the job, and the practice of some surety companies of issueing certified checks and taking notes in payment, the practice of some contractors who purchase equipment with notes and who then mortgage such equipment for funds with which to carry on their contract, and similar objectionable business practices that aid the irresponsible contractor. He described an agreement now in force in his state whereby material dealers offer a substantial cash discount for payment before the tenth of the following month, after which the total amount is due and payable. In case, under this agreement, the account is not then settled by the first

of the following month further supply to that contractor is stopped until the account has been paid. By the terms of the arrangement, no material firm may deliver materials to a contractor who has not settled all such claims held against him by other vendors. This plan, he said, appears to be working out very well.

Similar papers were presented at other meetings of the contractors, such as W. R. Smith's paper on depreciation of equipment, A. H. Hunter's paper on organization, H. H. Wilson's paper on "The Pernicious Triplets of Construction," Edmund J. Donegan's paper on over-expansion, and G. F. Schlesinger's paper on responsibility.

The Engineers Meet.—The engineers similarly held separate sessions and took up questions of vital import to their own professional work. The big topic of discussion appeared to be county highway management. Methods of paving the secondary roads were discussed at length. This is significant of the fact that as federal and state programs of paving the main highways progress toward completion the matter of improving the county feeder roads becomes of greater importance. The matter of snow removal also came in for some interesting discussion. In this latter subject, V. R. Burton, of the Michigan Highway Department, told of the experience of his state in snow removal, and cited costs to show just how far it was good economy to invest in drift prevention by means of snow fence and other measures, and how it is often cheaper to remove the drifts after they occur.

Secondary Roads.—W. W. Shields, Superintendent of Roads, Staunton, Va., was among those presenting papers on the matter of improving the secondary roads. He told of the use of the one-man power grader with 8 ft. blade in ditching, and told of the use of the gang patrol system for maintaining oil treated and penetration macadam roads. In his paper he showed the organization needed to patrol 150 miles of 12 ft. road from three to four times a season. This gang consists of a foreman, 6 laborers, and 3 truck drivers, with the necessary equipment.

R. G. Giles, chief engineer of concrete control, Blaw-Knox Company, Pittsburgh, read an interesting paper on the measurement of materials for concrete, and stated that a number of gradings of course aggregate should be provided. Accident prevention and other matters of interest to the engineer were also taken up at these sessions.

New Officers.—New officers selected for the coming year were announced before the close of the convention. The new president of the Association is Col. R. Keith Compton, director of public works, Richmond, Va. He takes office in May. W. A. Vanduzer, of Harrisburg, Pa.; D. B. Dimmick, Birmingham, Ala.; S. F. Beatty, Chicago; and Samuel Hill, of Seattle, Wash., were elected as new vice-presidents.

At the annual banquet, several noted speakers were heard, and James H. MacDonald, who has been called the "father of good roads," and who served the association for 25 years, was presented with a purse of $1,000 in gold, as a testimonial of appreciation for his efforts during the past quarter of a century.

The Road Show.—The show itself, as we have already stated, was bigger and better than ever before. To begin with, there were 33 more exhibitors this year than last year, which in turn was more than the year before. Enrollment totaled almost 20,000 before the doors were closed on the last day. The 338 exhibitors occupied 150,000 sq. ft. of floor space. This space was so utilized that in spite of the fact that this greater number of exhibitors installed more equipment in their booths than before, there was actually plenty of room around each machine. This made it possible for visitors to pass entirely around the equipment comfortably and safely, getting a better opportunity for its examination than was possible at previous shows in Chicago. Undoubtedly this better opportunity for comfortable inspection lead to greater sales. This indeed proved an important factor at the show.

Design Advances.—The art of the design of construction equipment is still in the development stage, and will continue to so develop for some time to come, if we are to judge by the new models shown this year. Greater efficiency, greater economy of manpower, greater portability, better mechanism, and added refinement were to be observed. More attention is being paid to equipment for use in the construction and maintenance of second class roads. Truck manufacturers are bringing out trucks particularly designed for the special requirements of the road builder. Equipment is being designed to move faster under its own power. Better trailers are being developed for the moving of heavy equipment. Dirt movers' equipment is being equipped with crawler treads for operation on soft ground and capacities are being increased.

Diesel Power.—There seems to be a slight increase in the use of Diesel power, and this may presage a general change in this direction in the next few years. There is some talk of manufacturers giving thought to the alternative of an internal combustion motor especially designed for operation with kerosene or crude oil as a fuel, but so far this is mostly talk. Gasoline motors are still used on the majority of equipment, and will continue to be used, it is probable, for many years to come.

In general, the designers seem to be following in the path laid down by the automobile designers. Machines are mechanically better each year. Ball and Roller bearings electric starters and pressure lubrication are becoming widely used. Castings are giving way, it seems, to lighter parts of alloy steel. Simplicity appears to be the rule. Several mechanical principles that are new and interesting were in evidence, such as the snow loader with arms that rake in the material, the power shovel with the boom sliding to the rear of the cab, the relay drive truck, and so on.

A Large Mixer.—The growing importance of central mixing was attested to by the introduction of a complete plant based upon a 56-S mixer.

Current advances in the art of controlling the quality of concrete are being met by more reliable equipment for the measuring of water, sand, stone, and cement. Better and simpler and more rigid road forms have been developed, and more accurate finishing equipment to be run on the road forms has been produced. Equipment operated by gasoline power is more flexible in operation since air or hydraulic controlled clutches and friction are being installed.

In all, the machines being brought out this year show improvements and refinement that promise greater efficiecy and economy and longer life.

Wisconsin Highway Guard Rails to be Changed

Accident reports showing that at least five people have been killed in the past season by the 4x4's on top of highway guard rails has led the State Highway Commission to order its division engineers to make a change over on all guard rails on state trunk highways in the state. According to Badger Highways investigation of each case where persons were killed in this manner developed that the person killed was literally inpaled on the jagged ends of the guard rails as it splintered from the impact of the crashing automobiles. The guard rail will be cut down to about 2½ ft. in height, leaving only the botton timbers. It is felt that this will be as effective as before, either as a warning or as a safety device and far less dangerous, to which is added the advantage of a greatly lessened maintenance cost.

Tire Wear.—Following extended tests made by the Washington State College, Kansas State Agricultural College and others to determine the amounts of tire wear on the different types of highway it was found that a mile of pavement which carries 1,000 cars per day, wears out $1,000 worth of tires in a year, while a mile of gravel road with the same traffic wears out $3,800 worth. The saving on tire wear alone, according to Badger Highways, would pay the interest on the cost of paving, where traffic exceeds 1,000 cars per day.

A Study of the Traffic Problem and Traffic Control

Methods Used for Finding the Needed Solution for Any Community Described

By WM. S. CANNING
Engineering Director, Keystone Automobile Club, Philadelphia

ANY problem of traffic, whether it be street congestion, signals, turning movement, or what not, can be properly treated only after a careful study of all factors involved is made by men experienced in such work. Legislative bodies and police officers can no longer effectively operate to relieve the general condition now prevalent over widespread areas. It is to the Engineering profession and those professionally trained in traffic problems, to whom the public must turn. Traffic control is an engineering problem. It can best be developed and directed by an engineering agency duly created for that particular purpose.

A number of large cities have now established some sort of engineering bureau or agency with trained traffic engineers in charge, to deal with traffic. Los Angeles, San Francisco, Chicago, Detroit, St. Louis, Buffalo, Pittsburgh, Washington, Boston and Essex County, New Jersey, all now have functioning traffic bureaus.

The traffic engineering bureau of any municipality should not be an organization functioning only once, but should be continuous. In general, it is undesirable to have such an agency connected with and subject to the police department. It is properly an engineering function and should be separately created as a bureau of the engineering department. It should have control and entire direction of the maintenance and operation of traffic control equipment, signs and signals. Traffic policemen should function as enforcement officers and aides in the general scheme of traffic control.

The Problem.—The ideal result to be desired in the handling and control of traffic, is a smooth, free flow in all directions with a minimum confusion and delays.

Variation in the volume, character and direction of traffic, as well as local physical conditions impossible to overcome, make necessary an accurate study of each problem as a basis for traffic rules. Traffic rules will be obeyed without delay and cheerfully, in direct ratio to their simplicity. Consequently, simplicity should be the foundation of all good traffic ordinances. Usually the driver is willing and eager to obey traffic laws, if he knows them, and to get out of the congested district as speedily as possible. Uniformity in traffic rules tends to simplify the general understanding of what is required to keep traffic moving. Special and unusual regulations are necessary in some instances, but these cases should be kept as few as possible. A traffic code should be enforceable, in that it must be consistent with the state code, each rule clearly worded and precise, so that no misunderstanding of the intention of the regulation can possibly exist.

Traffic Conditions Changing.—Traffic conditions are changing daily. The volume and character of traffic on Saturdays is different from that on the other working days of the week and all of these days are materially different from the Sunday traffic. Conditions existing on rural roads differ radically from those on urban streets. Hourly, daily, monthly and seasonal variations exist in all communities. New factors are being introduced continually. The number of motor buses is increasing with great rapidity on city streets and country roads. Four-wheel brakes on most passenger cars is a factor, recently introduced, that will have its effect upon the capacity of the streets. Solid tire trucks, their massive size and unwieldy dimensions, are factors to be considered. Increasing use of the closed car and more generous snow-removal programs prolong the heavy traffic season.

No traffic code prepared for present-day conditions can be permanent. It must be based on the present conditions, but built with as much foresight as is vouchsafed to us and must be flexible enough to meet changing conditions. Flexibility is essential if a code is to meet new conditions as they develop.

Regulations should be based on facts ascertained by observation and actual counts in the territory involved. The Hoover committee on a model municipal traffic ordinance is preparing and will have ready for publication early in 1928, a model traffic ordinance that is highly recommended to every local governing body.

The Traffic Survey.—A survey of traffic is the collection and the substitution for guess work of accurate facts and figures of an engineering character. It is a statistical and engineering study which should be made at frequent intervals in the same general area, in order to keep in mind and to portray the changes in character of traffic in any locality. If a traffic survey is to give adequate information for

Major General Mason M. Patrick, retired Chief of the Army Air Corps, has said that air travel will be safe within ten years. It is certain that street travel will be decidedly unsafe before that time. There is need for relief, well guided, systematic and comprehensive.

Since the effect of traffic is felt largely by business interests, it is only natural that business men should be the loudest in their calls for assistance, both upon public officers and upon various organizations which might be expected to deal with these problems. It is here that the automobile club can do the most work, according to the author, who believes that it is the automobile club's logical field. The automobile club, he claims, is the only agency of the motorist and business man alike (for almost invariably these two are one) that functions throughout the territory served, without regard for lines of political division. It is the only means, he states, of co-ordinating the actions and efforts of city and county, state, township and borough. It is even interstate in its functions and relations. With such a service in mind, this study is presented as a step toward the solution of the ever-growing problem.

No new thoughts are presented. The writer does not claim to have developed new ideas. He feels that he has acted more in the capacity of an editor than an author, in assembling and compiling the expressed or written thoughts of such deans of the traffic field as Dr. Miller McClintock, of the Erskine Bureau of Harvard University; Professor Lewis W. McIntyre, of the University of Pittsburgh; G. G. Kelcey, Traffic Expert of the American Gas Accumulator Company; K. W. Mackall, of the Crouse-Hinds Company; Burton W. Marsh, Traffic Engineer, Pittsburgh, and others. To such men as these he feels must the credit go.

The author's study of the subject, here summarized, will indicate the work being done by at least this one automobile club.

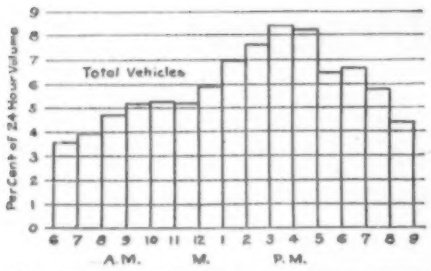


Fig. 1.—Hourly Variation in Average Rural Traffic

the development of a complete plan of traffic control, it must cover the entire field that will furnish information of value in treating the subject. No two days or localities are identical. Each locality has its own peculiar traffic conditions and physical problems. It is impossible to regulate the flow of traffic at one intersection by the rules laid down for application at another. The preliminary investigation should be concerned with the volume and capacity of the streets which are the logical arteries of travel, giving attention to

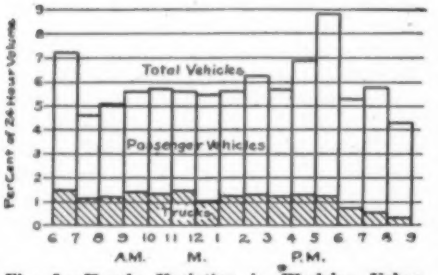


Fig. 2.—Hourly Variation in Weekday Urban Traffic

such obstructions in the street plan which cause choking or diversion of traffic flow.

Vehicular Counts.—The data upon which a subsequent analysis of the situation must be based can only be obtained by actual vehicular counts. Observers should be stationed at strategical points to enumerate the vehicles entering and leaving the area under consideration. Usually, all necessary information can be obtained from counts extending over a period of eighteen hours, from six a. m. to twelve o'clock midnight. Probably even this may be curtailed somewhat. Perhaps it will be necessary to extend the counts to the extreme hours on certain days only—say, Saturday, Sunday and either Tuesday or Thursday.

The observers should enumerate the vehicles traveling in each direction, the number turning right and left at each important intersection, and should separate main movements into several classes. In most instances, counts of pasenger cars, trucks, motor buses, street cars and horse-driven vehicles will afford all necessary information. Sometimes it may be necessary to count pedestrians or taxicabs or some other mode of tranportation, but such instances are unusual and are only necessary when studies for specific subjects are being made.

Hourly Variation.—There is inserted herein Fig. 1, a typical chart showing the average hourly variation in traffic on rural roads. Other charts, Figs. 2, 3 and 4, show typical hourly variation of traffic on the streets of small industrial cities of from 15,000 to 80,000 population. It is seen that in order to secure the data to compile such charts, observers should separate their figures into columns for each hour of the day.

From such data can be obtained the volume of peak traffic for which special regulations should be made. Traffic at lesser or average hours can be handled by other means, and the hours of least traffic can probably be directed by a third method. In other words, maximum traffic may be directed by officers, average traffic may be controlled by automatic traffic lights, and minimum traffic regulated by flashing lights or by universally known rules.

Daily Variation.—The chart, Fig. 5, shows the typical variation of urban traffic from one day to another. Fig. 6 shows the same data on rural roads. Generally speaking, it may be said that the five full working days of the week are alike as to volume and character of traffic. Saturday, usually a half working day, is different, and Sunday traffic is radically different from all the others. Certain cities and towns have special days on which the volume and character of traffic may be different: market days mercantile mid-week holidays and the like. Such data furnishes the basis for other special regulations, days on which traffic officers must be on duty an extra number of hour, traffic lights must be operated longer or may be turned off entirely.

Monthly Variation.—As a matter of general information, probably not for any practical use in the average traffic survey, there is included Fig. 7, a chart showing the average monthly variation of traffic in rural communities.

Seasonal Variation.—Naturally in the vicinity of Philadelphia highway travel is much greater in the Summer than in the Winter. The first peak of traffic may be said to be on Memorial Day; then the season has started. Every Sunday will show a small peak of its own. The big mountain usually obtains on July Fourth. The Summer months are all high. The final peak of the year is usually on Labor Day. Traffic thereafter rapidly declines to the average and minimum months. An early Spring or a late Fall will be reflected in the traffic.

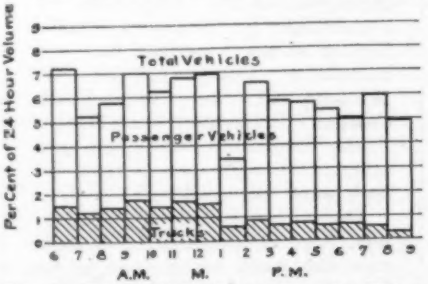


Fig. 3.—Hourly Variation in Saturday Urban Traffic

Traffic Flow Map.—A traffic flow map is a plan of the streets of a municipality, with the volume and direction of traffic flow shown graphically thereon by lines of width to correspond with a fixed scale for a number of vehicles. The traffic flow map may be based upon either of two sets of figures, depending upon the purpose for which it is made. If the map is to be used to indicate maximum traffic, then the maximum figures, always regardless of the hour or day of the week, must be used. If the map is to be used for comparison over considerable periods of time, then the average figures for day or month should be used. Generally it will be the former case that will be of instance, as the demand is for relief at hours of maximum flow.

Making Traffic Flow Maps.—In making a traffic flow map, it is important that the area in question be portrayed to a true scale and that all natural or artificial obstructions be completely and correctly shown. A narrow viaduct over a railroad track or a permanent trolley safety zone may have an important bearing upon the flow of traffic and upon steps taken to remedy the conditions.

Directional Variation.—Direction of traffic flow should always appear upon such a map. This may be most easily done by plotting the volume of northbound traffic on the east side of the street and of the south-bound traffic on the west side of the street. et cetera. A typical traffic flow map, illustrating these points, may be seen in Fig. 8. An inspection of traffic flow maps at once shows what major intersections are strategic points at which definite studies should be made. It is at these points that the studies will reveal the necessity for traffic control of the highest type.

Speed of Traffic.—Observation of the speed of vehicles should be made and records kept of the flow maintained between the various points along the route. It is not always the case that best results can be obtained by merely speeding up the flow. While a mini-

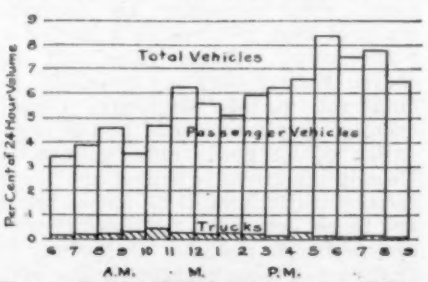


Fig. 4.—Hourly Variation in Sunday Urban Traffic

mum rate of movement should be constantly maintained, a careful examination of the graph in Fig. 9 will show that maximum volume consistent with safety in a single lane of vehicles can best obtain at speeds between thirteen and eighteen miles per hour. The general rule is that during hours of heavy traffic the most efficient results will be secured by reducing the mass speed and by increasing speed as the traffic load reduces. This produces, usually two or three timings: one for the peak loads, one for the intermediate load, and still another or none at all for the light load.

Origin and Destination.—Origin and destination studies of traffic between the various part of the city, together with the knowledge of routes ordinarily followed, are of value. Such studies might be made by police officers or by noting the location of the residence of the ownership of cars parked in the central district, as revealed by their license plates. Studies should be made of the character of this traffic, as well as of the volume and destination, in order to devise some logical alternate or relief routes.

Pedestrians.—Regulations for the control and protection of pedestrians have become a vital factor. At some time during each day everyone becomes a pedestrian. The movement of pedestrians at intersections should be controlled, not only by lights, but should be concentrated between definitely marked cross-walks. In some rare instances pedestrian traffic is so great as to require a special interval. Some cities give pedestrians absolute protection by means of separate intervals, during which all vehicular traffic is stopped, but they do so frequently at the cost of considerable delay and resultant traffic jams.

Dr. Miller McClintock, Director of the Erskine Foundation for Traffic Research of Harvard University, who designed the system of pedestrian control in Los Angeles, believes that this type of regulation is applicable under certain conditions.

In a recent address Mr. E. B. Lefferts, of the Automobile Club of Southern California, said: "Our present regulation calls for the prolongation of the sidewalk lines across the street. These lines are divided in the center by another white line, making in effect a large letter 'H' between the curbs, with the cross bar of the letter in the center of the street. A motorist is compelled to stop and remain standing while a pedestrian is in that half of the lane on the side of the street upon which the motorist is traveling, until the pedestrian has passed beyond the path of the vehicle."

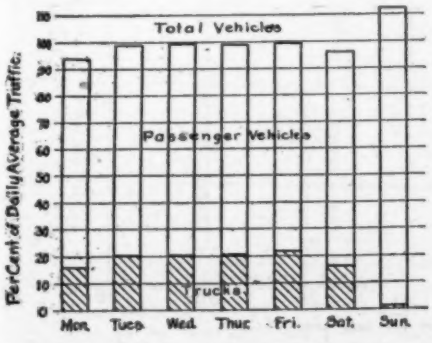


Fig. 5.—Daily Variation in Urban Traffic

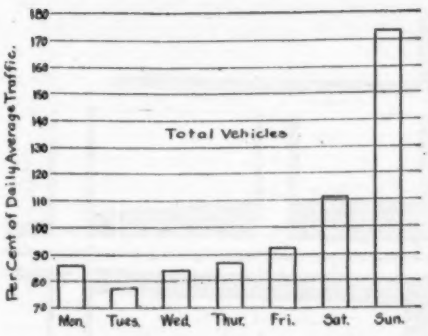


Fig. 6.—Daily Variation in Rural Traffic

The courts all over the country have ruled that a pedestrian, within his proper lane or cross-walk, has right of way over all other traffic movement.

Education.—The important principles of traffic may be summarized as the "Three E's" Education, Engineering, Enforcement. The operators of motor vehicles cannot be expected to understand and realize unusual requirements at intersections. Sufficient information should be afforded by means of signs and pavement markings, all of which should be so placed as to be easily and quickly seen. Every advantage should be taken of opportunities to give newspaper publicity to traffic regulations. A consistent campaign of education in the schools, by means of a course of lectures given at frequent intervals throughout the school year by a traffic officer, should be inaugurated and carried out.

Under the laws of North Carolina, the State Highway Commission was ordered to have a sufficient number of copies of the state traffic laws to supply each high school teacher in North Carolina. The digest of traffic laws will be studied each week in the schools of that state.

Every city's traffic organization should include a Public Relations Department, whose function it would be to use constantly the movies, radio, newspapers, pamphlets, flyers, speeches and every medium obtainable to educate the public on essential traffic points, to prepare the ground for traffic innovationes and to develop and retain the co-operation of the public. It was by such means that pedestrian control was established and is still effective in Los Angeles.

Accidents.—Studies of traffic accidents should be the basis for safety recommendations. From the statistics of the localities of accidents can be platted danger maps of the city and it is at the points indicated on the map that the greatest amount of attention should be given. Accident or danger maps in cities usually show that serious accidents are rare in the central business district but are frequent on thoroughfares radiating from the business district and passing through the congested residential localities.

A record of accidents in large cities shows that before four p. m. the number of accidents is relatively low in proportion to the volume of traffic. After four p. m. particularly between five and six p. m. there are more accidents than at any other time during the day. There is shown in Fig. 10 a chart prepared by Mr. Charles M. Upham, Director, American Road Builders' Association. Mr. Upham estimates that during the five years ending December 3, 1926, the staggering total of 3,446,370 persons were injured and 114,879 killed in traffic calamities, most of which were avoidable. The yearly record follows:

Year	Killed	Injured
1922	19,203	576,090
1923	22,621	678,630
1924	23,291	698,730
1925	24,462	733,860
1926	25,302	759,060

Mr. Upham places a conservative figure on the economic loss at nearly three billion dollars.

Freight Movement.—The movement of trucks and freight on the streets has received scant attention to date, but there is a definite tendency to restrict trucks to certain streets and the handling of freight until after nightfall. A suggested plan of action for the relief of certain main arteries is the preparation of a series of maps of the city showing improved trunk highways suitable for their needs. Such a map, placed in the hands of traffic directors at manufacturing and trucking companies, may have a tendency to centralize truck traffic on certain definite routes and thus segregate it from the passenger vehicle movement.

When traffic is directional during the peak hours, a prohibition of all park-

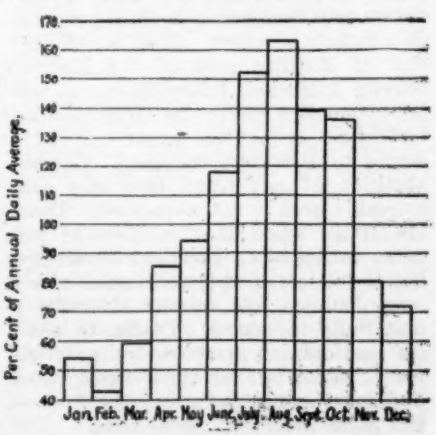


Fig. 7.—Monthly Variation in Rural Traffic

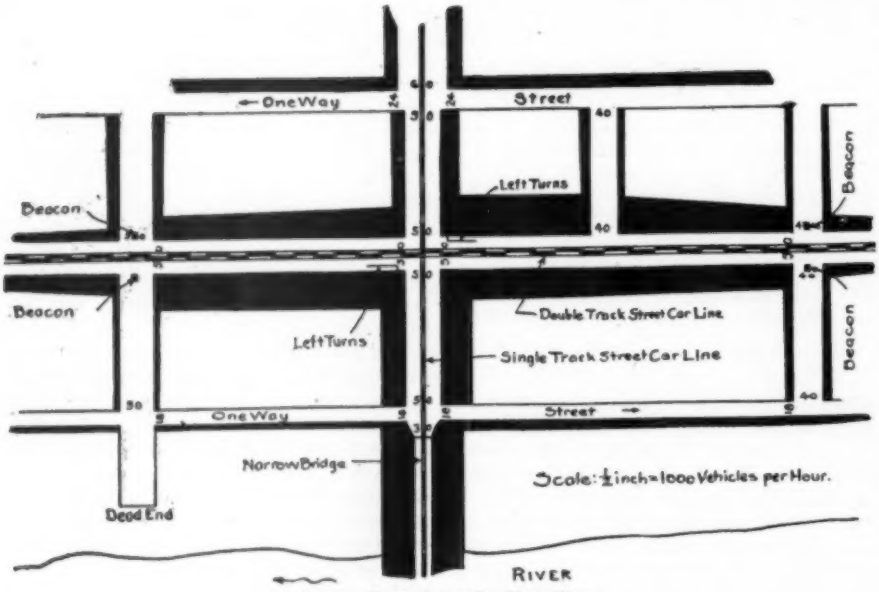


Fig. 8.—Typical Traffic Flow Map

ing on the flow side of the street may afford relief.

Alignment of Traffic.—A street having sufficient width to handle two lanes of traffic in each direction is often converted into a one-lane street because the first car in the line stopped for cross traffic will straddle the two lanes and the other cars will line up in disorder back of it. To offset this, it is recommended that pavements be marked in lanes for at least fifty feet back of the intersection, which will tend to line up at least the first eight cars, four in each line.

Flexible Lanes.—It may be possible that on two-way streets an additional lane may be made available by moving the divisional line, as is done on the Delaware River Bridge. The city of Cleveland has tried such a plan with success. Traffic lanes marked on the pavement, and drivers required to stay in one of these lanes, will have the effect of speeding traffic.

Restriction of Turning.—The elimination of left turns may in some instances be needed. The elimination of all turns in some areas where thousands of pedestrians are using crosswalks may sometimes be indispensable as a safety measure. This has the effect of shifting part of the load at heavily trafficked intersections to adjacent corners where the cross load interference is not so great. It is a device to distribute the load. General abolition of left turns over any considerable area is not advocated. There are times when the abolition of left turns works to an excellent advantage, but if the left turn is prohibited over a long distance, the volume of traffic is materially increased. Traffic, to reach its destination, must go by a longer route, make two or three right turns, and must cross and delay the flow on the main artery at some time.

Grade Separations.—Grade separations are being advocated for busy intersections. Detroit now has a separation of grades at East Grand Boulevard and at East Jefferson Avenue, and is developing others. In St. Louis there is an over-pass where the boulevard parkway passes over a major street at the entrance to Bellerive Park. Bethlehem, Pennsylvania, has an elaborate over-pass which handles traffic at five intersections. St. Joseph, Missouri, has adopted grade separation as a major method of clearing traffic. San Francisco has an over-pass at the foot of Market Street and the Embarcadero. The city also has a pedestrian viaduct for the passengers who enter or leave the Ferry Building from the central business district and the Eastbay communities. In Cincinnati there are eleven over-passes where one street is carried by a bridge or a viaduct over another street. In the case of this city, the original reason for the over-pass was not for reasons of traffic but because of topography.

Parking.—Streets are primarily provided for the use of the general public as a means of communication for pedestrians and for the transportation of persons and merchandise. The right to use the streets, including the right to park, is subject to civic and public welfare. As traffic density increases, every effort should be made to expedite movement and make it more safe by the use of pavement markings, traffic signs and signals, the designation of one-way and through streets, the elimination of turns and the appointment of adequately trained traffic officers. The right to move cars should have precedence over the right to store cars on a public highway.

Parking is one of the most difficult elements in traffic control. The retail business and curb parking are important factors in parking regulations. A considerable amount of parking which interferes with traffic movement is tolerable if such parking contributes materially to the business. On the other hand, if it is found that curb parking contributes but little to the retail business houses, it may be well to regulate parking by restriction. Curb parking which is entirely unrestricted as to time limit cannot in the long run be beneficial to retail trade.

The factors entering into such conditions can be determined by a "modes of transportation" study. Such a study can best be conducted by business houses themselves, by having their em-

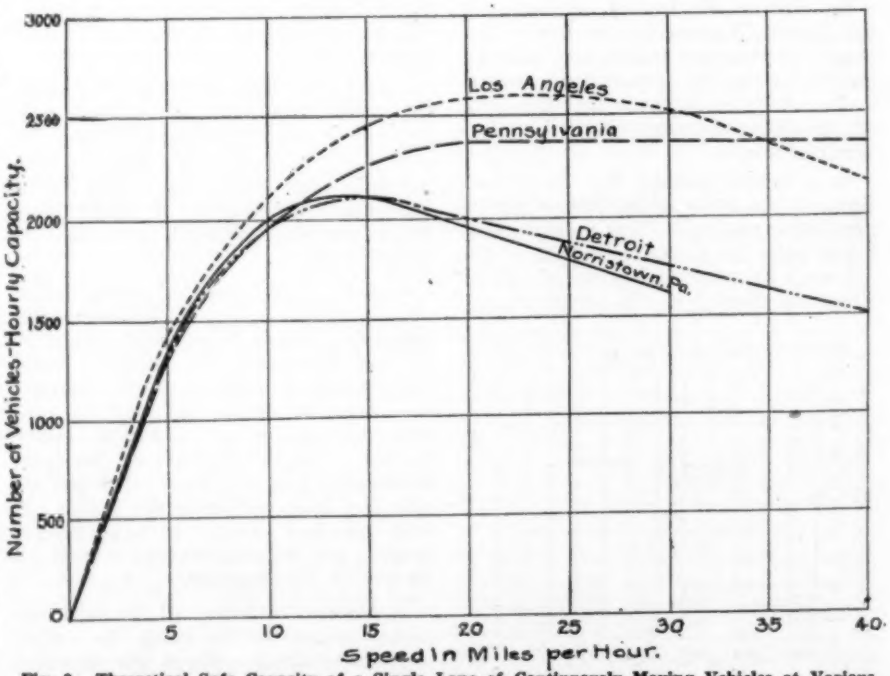


Fig. 9.—Theoretical Safe Capacity of a Single Lane of Continuously Moving Vehicles at Various Speeds

ployees ask patrons in a casual way, during the ordinary transaction of business, how they arrived, and if by motor, where their cars are parked. Any relief gained by the elimination of parking is largely lost within a short period of time because motor vehicles are increasing in number so rapidly.

Parking Areas a Necessity.—It is known to be a fact that in cities where parking is prohibited on certain streets to avoid congestion, the rules are frequently disregarded and that in some instances officials are at a loss to cope with the situation. Enforcement of the law, it would appear, results in wholesale arrests and the invoking of the public's ire.

A better way is to provide municipal parking areas where vehicles may be parked either free of charge or at a nominal charge per hour. If cities have adequate funds to provide free parking areas, this means would seem the most desirable, for motorists who stay down town for only on hour or two are usually averse to paying for parking and generally are the most flagrant violators of the "no parking" rule.

The Borough of Norristown has provided three such parking areas—free for all. The public is directed to these places by a large number of signs erected by the Keystone Automobile Club in carrying out the recommendations of the traffic survey recently completed there by the club.

The state of Minnesota has in force an act which authorizes "certain villages and cities to acquire land for use as a place within which to tie horses and park automobiles."

Traffic Regulation.—The first step in the regulation of traffic is the direction of its flow into special channels by means of "silent policemen," light-houses, beacons and buttons, by pavement markings, or devices of such nature. The second step, now becoming general, is the "boulevard stop" and through traffic streets.

New Jersey has a law, recently effective, which names all state highways and all streets or highways upon which are operated street cars or bus lines, and also certain other streets, as "through traffic streets." Pennsylvania's new vehicle code, effective January 1, 1928, authorizes the Secretary of Highways and the Councils of cities of the first, second and third classes to designate "through traffic streets." Such laws have long been in force in Chicago and other cities and have been deemed successful.

Under such a law, and where proper signs are in place, vehicles must come to a full stop before entering upon or crossing the through traffic street. This gives the large number of vehicles on the through street a superior right to the small number on the side street. It is seldom that any considerable delay will result from such a law, and it does aid materially in reducing accidents. To this point, all traffic may be said to be regulated and directed; not controlled.

Automatic Lights.—The first step in the control of traffic is the "stop and go" signal, whereby through movement on one street is stopped while that on the cross street is permitted to proceed. In this movement, unless the volume is very great, all forward and turning movement may be permitted on the "go" signal but no movement should be permitted on the "stop" signal. The signal lights should be regulated to the volume of traffic approaching the intersection from each of the streets and should be in operation only at hours when the flow for which they have been regulated is expected.

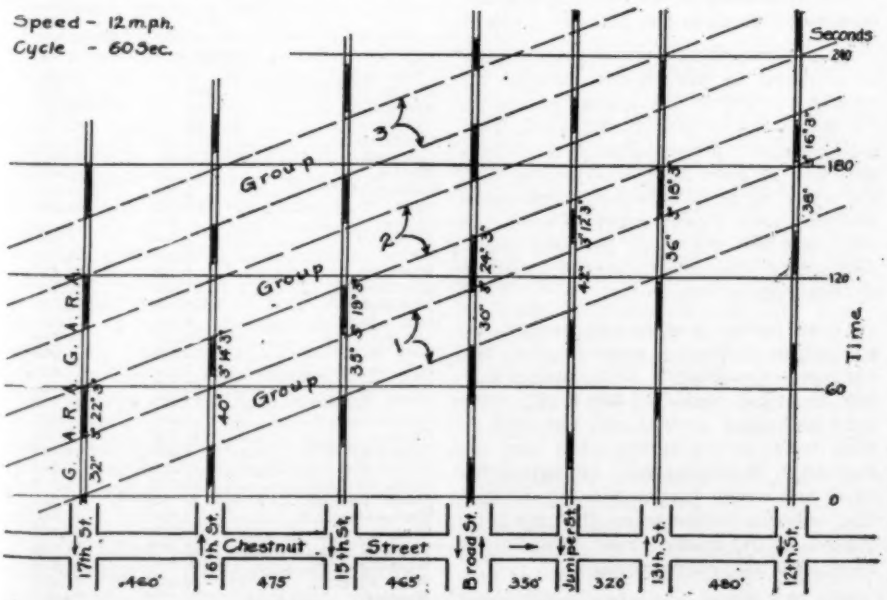


Fig. 11.-Typical Theoretical Timing Diagram for One-Way Street

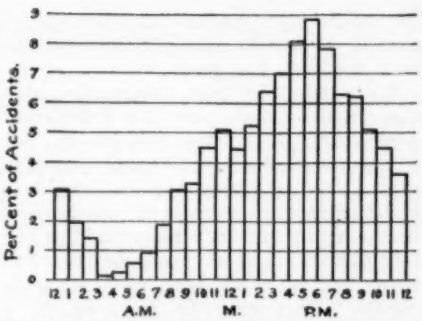


Fig. 10.—Accident Chart Showing Dangerous Hours

At hours of lesser traffic the lights may be operated as a flashing signal similar to the light-house or the beacon light. In the hours of greater traffic flow than that for which the signal was regulated, it should be operated by a traffic officer.

Location of Lights.—Early in the history of the automatic light it was placed upon a pedestal, frequently of concrete, in the center of the street. On wide streets, not over-crowded by traffic, such location affords a safety island for the protection of pedestrians crossing the street, but on narrow streets it is not only a menace to the motor vehicle operator, but creates a "bottle-neck" sometimes narrowing the street to a single lane of traffic in each direction. A further objection to such location of the lights is that they permanently fix the center line of the street and are obstacles to the possibility of the flexible or movable center line.

Another objectionable location for the signal light is upon cross wires or arms, suspended over the center of the street. In order that a light so placed may clear the top of a loaded vehicle, it must be so high that the driver of the average car of today must use a periscope or bend almost double to see it when he is stopped awaiting the proper signal. The ideal and proper location is four separate lights, affixed to posts, about eight or nine feet above the street level and planted on the opposite right curb line. They may then be readily seen and are where the eye of the driver should be trained to observe a vehicle approaching from his right.

Left Turns.—Traffic at an intersection, in each of the four directions of approach, has three movements: straight through, right turn and left turn.

At an ordinary intersection, uncontrolled, these twelve movements take place with little confusion, traffic weaving in and out. When the volume of traffic becomes so great that this movement cannot take place without too much confusion, then control is necessary. When control does become necessary and is instituted, it is rarely necessary to go further than to divide

the twelve movements into two parts; that is, to permit straight through and both turns on the green.

It is possible that sooner or later there will be some need for a separate period for left turning movements, but if these movements are made from the center of the street and the street is wide enough to permit of movements to the right of the vehicle making the left turn, it is most probable that left turns can be made without a separate signal. This may be true up to a certain point, where left turning movements congest traffic beyond the capacity of the street. In that case, studies should be made of the possibility of eliminating the left turns.

The timing of lights in proportion to the volume of traffic should take into consideration both the proportion of pedestrians and of vehicles turning at the intersection.

Long Cycles Vs. Short.—Long cycles have a tendency to create the desire to "jump the lights" either on the part of the pedestrians or on the part of the motor vehicle operators. As a result, accidents may be expected. Short cycles have a tendency to expedite movement and provide greater safety.

Justifying Signal Lights.—What volume of traffic justifies the use of a signal light? In smaller cities and in rural communities particularly, we have too many signals. In many places the volume of traffic justifies the use of signals at a given spot only occasionally, perhaps once a week. To flash "stop" signals when there is no need for them encourages violations. The great mass of American motorists observe signals very well, indeed even when there is no need for them, but if we increase the signals too much there will be a strong reaction against them.

It is impossible to definitely determine and set up a group of figures for volume of traffic on either main or intersecting highways at which, when attained, traffic lights should be installed. Too many factors enter into the problem; width of traveled way, alignment, grade, speed and volume, character and many others.

It is believed that signal lights are not justified until the volume of traffic on the intersecting street, awaiting entry to or across the main artery under a "through traffic stop" law, is so great that it cannot safely enter or cross the stream of traffic on the main artery.

Survey for Traffic Signals.—A thoroughgoing and complete traffic survey should be made before the installation of any traffic control system on a main artery or in any important business district. Such a survey must be made under competent engineering guidance. It should include such factors as the following:

Volume of all classes of traffic on each street, including volumes of turning movements made by various kinds of vehicles.

Average, maximum and minimum speeds for various classes of vehicles during the various hours.

A study of street car schedules, speeds, delays, stops, and loading and unloading characteristics.

Study of turns (especially left turns) and how to most efficiently provide for them at each corner.

Study of traffic lanes and of their capacities and relative use under different conditions.

Study of special intervals used by officers at unusually shaped or otherwise special intersections.

A study of special interference or obstruction factors.

Studies to determine the most desirable length of cycles for all corners.

Study to determine the best time-setting for starting the green light at each corner.

Study to determine the best apportioning of the cycle at each corner, including studies of traffic officer's intervals at various times during the day and analyses of time demands of critical lanes on each street, especially where there are no officers.

A study of all electrical problems involved, including availability of duct lines, local pick-up of power and the best electrical conrtol apparatus design.

Systems of Control.—There are three systems of control now in use to coordinate a group or series of traffic lights. They are:

1. Synchronous control.
2. Progresive control.
3. Co-ordinated control.

Synchronous control means that traffic moves simultaneously on all north and south streets while all east and west traffic stops, followed by the simultaneous movement of all east and west traffic while north and south traffic stops.

Progressive control means that the colors appearing in each block are the reverse of those in the preceding block.

An ordinary synchronous system may be changed to progressive control by simply reversing the signal colors at the beginning of each traffic block. This is a straight progressive control system and is open to the objection that the split in time between north-south and east-west timing must be even. In this case the distances between intersections of the street treated must be approximately even also.

Co-ordinated control approaches the perfection of timing, since it gives the utmost in flexibility. With such a system the total period of the traffic cycle may be varied at will and the split in time between the north-south and the east-west directions may be varied for each and every intersection if desired. The only limitation being that the total period of the traffic cycle must be the same for all intersections.

Fig. 11 shows a timing study chart of a typical street with the lights operating and traffic moving uider co-ordinated control. Under synchronized progressive or co-ordinated control, the movement of traffic is, of necessity, regulated by the speed of the slow-moving vehicle. Without consideration for the slow-moving vehicle, the purpose of co-ordination is defeated. The necessity for segregation of trucks and freight movement into especially provided lanes, or slow-speed streets, is therefore apparent. Street car movement and stopping are important factors for consideration. Street railway companies generally will enter into the movement to increase the running time of their schedules with hearty co-operation.

Forest Road Fund Apportioned

Apportionment of Federal forest road funds totaling $7,500,000 among the States and Territories which contain national forests, has been approved by the Secretary of Agriculture. The funds were authorized by Congress in 1926 for appropriation for the next fiscal year which begins July 1, 1928.

Of the total of $7,500,000, there was authorized $4,500,000 for the Forest Highway Fund, to be expended in the construction and improvement of roads in and adjacent to the national forests, of primary value to the public for travel, etc., and $3,000,000 for the Forest Road Development Fund, to be used in the construction and maintenance of roads required mainly for the development, protection and administration of the forests.

The States containing national forests and the amounts apportioned to each State from the two funds for the next fiscal year are as follows:

State	Total Apportionment of $4,500,000 Authorized	Apportionment of $3,000,000 Authorized
Alabama	$ 4,214	$ 11,932
Alaska	466,446	24,898
Arizona	284,884	136,871
Arkansas	38,197	41,181
California	671,088	441,067
Colorado	329,051	148,012
Florida	11,902	23,627
Georgia	7,298	18,919
Idaho	502,403	649,397
Illinois	383	
Kentucky	1,540	2,123
Maine	1,329	6,681
Michigan	3,450	1,628
Minnesota	27,946	32,702
Montana	394,994	285,157
Nebraska	4,604	1,171
Nevada	93,883	4,205
New Hampshire	17,729	21,993
New Jersey	810	421
New Mexico	208,313	121,185
North Carolina	12,439	34,773
Oklahoma	2,068	342
Oregon	621,758	453,141
Pennsylvania	6,838	6,262
Porto Rico	520	252
South Carolina	2,293	5,203
South Dakota	39,195	19,610
Tennessee	11,626	30,380
Utah	168,329	50,564
Virginia	15,591	27,948
Washington	330,255	303,624
West Virginia	5,603	21,038
Wyoming	213,071	74,693
Grand Total	$4,500,000	$3,000,000

Important Developments During the Past Year in Highway Research

A Summary of the Reports Presented at the 7th Annual Meeting of the Highway Research Board

By A. C. ROSE
Associate Highway Engineer, U. S. Bureau of Public Roads

At the present time the Highway Research Board of the National Research Council has eight committee conducting research studies of various problems in the highway field. At the recent 7th annual meeting of the board some very interesting reports of the progress made in 1927 in these studies were presented. An interesting summary of these reports is given in the January Public Roads, the official publication of the U. S. Bureau of Public Roads, by A. C. Rose, an Engineer of the Bureau. The main points in Mr. Rose's summary are given herewith.

AUSTIN B. FLETCHER, chairman of the committee on causes and prevention of highway accidents, in his introductory remarks, preliminary to the reading of the detailed papers by the six members of his committee, stated that motor-vehicle accidents were increasing at the rate of 5 per cent a year, and for this reason it did not seem necessary to emphasize the need of highway-safety precautions. In order to make the investigations of the committee as comprehensive as possible, there were included in its membership not only highway engineers but also a psychologist, a physicist, and an automobile manufacturer.

Motor Vehicle Accidents.—S. J. Williams, director of the public safety division of the National Safety Council, a member of the committee, estimated motor vehicle fatalities in 1926 at 23,000, and stated that they are growing at the rate of 1,000 a year. In the cities two-thirds or more of the accidents involve pedestrians, while on the rural roads the corresponding proportion is one-half. The speaker stressed the need for more accurate information concerning the causes of accidents since, unfortunately, only about six States require systematic accident reports and statistics. To supply this deficiency, Mr. Williams advocated the adoption of a standard reporting system that would consist of: (1) An individual report card, and (2) a tabulation form for summarizing the cards monthly and annually. For small municipalities, tally sheets would be used, and for large States the punch card system would be more economical.

In trying to arrive at the causes of accidents Mr. Williams believes it is a mistake to try primarily to fix the personal responsibility. He thinks it a much better plan to collect data as to the circumstances or facts in each case in order to eliminate the element of personal judgment. He concludes, however, that the most refined accident statistics are at best only the first step in solving the problem, the final solution of which depends upon the application of remedial measures based upon a scientific study of the accident statistics.

M. G. Lloyd, chief of the safety section of the United States Bureau of Standards, delivered a paper on the standardization of motor vehicle equipment as a means of reducing the accident risk. He believes that headlight devices should be regulated by the States and not by Federal or municipal authorities.

Motor Vehicle Lights.—The general specifications now in use are those adopted by the Illuminating Engineering Society in 1920, and revised in 1922. These have also been adopted by the engineering standards committee. There are two basic ideas included in these specifications:

1. An attempt to avoid throwing excessive light into the eyes of the driver of an approaching automobile.

2. An attempt to throw the maximum amount of light upon the highway.

The defect in the present regulations is that while they require adequate equipment they do not include sufficiently drastic regulations concerning the maintenance of the apparatus in proper adjustment. This deficiency, said Doctor Lloyd, should be remedied. The depressible beams of light, now being developed commercially, involve legal complications because they are in conflict with the existing laws based upon fixed beam lights. The adjustment of headlights involves two factors: (1) Proper aiming, and (2) proper focusing.

The speaker continued with a discussion of tail lights and rear signaling lamps and concluded with a reference to the new code which had been prepared for testing and regulating brakes. With the four-wheel brakes in use, Doctor Lloyd believes the requirements relative to stopping distance could be made more severe.

Psychology a Factor in Accident Prevention.—In delivering the third section of the accident report, Knight Dunlap, professor of experimental psychology at Johns Hopkins University, said that psychologists were interested in the sense of preception and the formation of habits. It is important in reducing accidents to develop safety habits which become instinctive. The time lost in thinking of the action required is often critical. Unnecessary and misplaced signs cause accidents not only at the point at which they are situated but also at other locations, because they breed a contempt of warning signs which leads to the development of unsafe driving habits.

In commenting upon the proper colors for luminous signals and fixed signs, Doctor Dunlap stated that the entire retina of the eye is not equally susceptible to color. For all practical purposes, the rapid discernment of color is limited to the central vision. Yellow and blue are excellent colors for this purpose, but the generally used red and green are tolerably satisfactory. In order to improve the colors now generally accepted, the green should be made as blue as possible, and then, if the cautionary yellow color could be abandoned, it would be better to shade the present red into an orange-red color.

With regard to refusing licenses to color-blind people, the speaker said it is impracticable to solve the problem by refusing to issue licenses. Color-blind persons with some preliminary training can pass a casual examination and only a thorough investigation by a highly trained physician or psychologist can detect vision defective in regard to color. Furthermore, normal persons, when under the strain of an examination, have their color sense sometimes temporarily disturbed.

Motor Truck Accidents.—John C. Long, secretary of the street-traffic committee of the National Automobile Chamber of Commerce, gave a report of a study limited to motor-truck accidents in Hartford, Conn., during the period of January 1 to 30, 1927. All accidents involving property damage of $10 or more were included. The conclusions show that drivers were at fault 57 per cent of the cases. Difficulty was experienced in obtaining information

because of the fear of unfavorable publicity on the part of the motor-truck owners. This difficulty was removed when it was explained that the aim was not to fix personal responsibility but to determine the causes of accidents and to reduce these by adequate instruction in a motor-truck driver's school.

A. N. Johnson, dean of the University of Maryland, showed lantern slides giving the results of a method used for measuring the relative efficiency of traffic flow through street intersections under various conditions of control, such as traffic lights and police officers. The speaker believed that the flow of traffic through street intersections is a fundamental consideration both with respect to safety and to the speeding up of traffic.

Grade Crossing Accidents.—W. G. Eliot, 3d, of the Bureau of Public Roads, concluded the accident reports with a statistical study of the number of grade-crossing accidents in the United States. The data indicated that grade crossings are responsible for 10 per cent of all motor-vehicle fatalities, but only 1 per cent of the total injuries. The number of rural and urban grade-crossing accidents are almost equal, but 65 per cent of the fatalities are rural. One explanation of this is the slower speed of trains in cities. Mr. Eliot estimates that only 40 per cent of traffic accidents of all kinds occur on rural highways, and that grade-crossing accidents represent 16 per cent of the total on rural roads.

Studies Relating to Vehicle Operation.—Professor Agg, the chairman of the committee on economic theory of highway improvement, in summarizing the reports of individual members of the committee, stated that the paper on the measurement of tractive resistance, although not perhaps a final report, may be considered to represent the completion of the project. Roughly, the report dealt with four factors: (1) Rolling resistance, influenced by the condition and kind of tire; (2) impact, as affected by the distortion or character of the road surface; (3) air resistance; and (4) the coefficient of friction between the tire and the roadway surface.

Relative to the progress report on the cost of operation of automobiles, Professor Agg stated that the records show lower costs per mile as compared with figures obtained four or five years ago. This was believed to be caused by the greater distance traveled annually by the average driver and also to the improved character of motor vehicles.

It was announced that the report on the effect of roadway surface on tire wear was not ready for presentation but that it was expected to be completed in time to be made a part of the printed proceedings.

Professor Agg referred to studies his committee has made on the contribution of common-carrier busses to State-road funds. The information so far tabulated had been obtained from the records of the public service commissions of Michigan and Iowa. In Iowa the contribution of the motor bus per ton-mile is decidedly greater than that of privately-owned automobiles. In Michigan the reverse is true. The committee will attempt to determine the proper contribution.

Wind Resistance to Motor Vehicles.—L. E. Conrad of Kansas State Agricultural College delivered his report on wind resistance to motor vehicles. In summarizing available information on the subject, he pointed out that only three investigations are known to have been made in the United States, those of: (1) The United States Bureau of Standards; (2) the engineering experiment station of Kansas Agricultural College; and (3) the engineering experiment station of Iowa State College. Some work has also been done along similar lines in Germany.

Professor Conrad concludes that for a straight head wind the resistance for ordinary passenger cars may be considered as $0.0025V^2$ pounds per square foot of projected area. In this formula V is equal to the velocity of the automobile in miles per hour. He believes that an even exponent of V will serve as well as a fractional one for all practical purposes. Studies are to be continued on the effect of side and quartering wind.

Tractive Resistance.—H. B. Shaw, of North Carolina State College, gave a résumé of research on tractive resistance. An attempt is being made to formulate a practical theory based upon the results of outstanding studies. As an interesting side light he recalled that Sir Isaac Newton, years ago, developed theoretically a value for air resistance that has since been confirmed experimentally. The present experiments indicate that tire displacement resistance decreases with increased air pressure in the tire which results from the heating which takes place when a vehicle is in motion. Tire displacement has been found to increase at a greater rate than the increase of the weight on the tire.

Structural Design of Road Studied.—A. T. Goldbeck, of the National Crushed Stone Association, chairman of the committee on structural design of roads, because of the limited time, summarized the reports of the members of his committee. These papers covered 19 subjects. With regard to the loads on highways the speaker stated that with the same total load the rear wheels of four-wheel trucks transmit twice as much load to the pavement as either pair of rear wheels of the six-wheel truck.

The report on subgrade studies outlined methods of soil identification from known proportions of the separates of sand, silt, and clay. The slaking value test was mentioned as indicating the susceptibility of soil to erosion. A simple precolation test was considered to be adequate to determine those soils which might be drained with tile. The report continued with a discussion of the behavior of subgrade soils when subjected to various moisture conditions. Granular subbases were mentioned as an efficacious method of compensating undersirable subgrades. The studies of landslides, and the sand-clay, gravel, and top soil surfaces of the Southern States were outlined.

Rule of Thumb for Bituminous Macadam.—A rough practical rule given for the construction of bituminous macadam surfaces was that the depth of the surface course in inches should be equal to the maximum size of stone in the surface course, and the number of gallons of bitumen per square yard of surface might be estimated at the same numerical figure. Thus for a 1½ in. surface course, the maximum size of stone would be 1½ in., and there would be required 1½ gal. of bitumen per square yard.

With respect to the design of concrete pavements, the speaker stated that this is affected by the character and condition of the subgrade, and that the latter must be evaluated in order to make possible a more accurate cross section. The maximum wheel load is now recognized as causing the stress for which the pavements must be designed. There is a noticeable tendency on the part of highway engineers to reduce the size of concrete pavement slabs with longitudinal and transverse joints.

Mr. Goldbeck concluded his summary with comments concerning reinforcing and curing of concrete pavements, and methods of constructing brick pavements.

In a general discussion of the report of the committee on structural design of roads, C. H. Moorefield, State highway engineer of South Carolina, stressed the importance of considering the subgrade and emphasized the need of further knowledge of subgrade soils and their behavior as a prerequisite to adequate pavement design.

Character and Use of Road Materials.—The report of the committee on character and use of road materials was presented by the chairman—H. S. Mattimore of the Pennsylvania State highway department. The paper discussed six factors in the control of the construction of concrete pavements: (1) Retesting of cement stored over three months; (2) fine aggregate; (3) coarse aggregate; (4) proportioning of materials; (5) curing the finished pavement; and (6) tests of the finished pavement.

The quantity of Portland cement used, said the speaker, should be carefully checked at the plant, on the job, and by counting the empty sacks. With regard to fine aggregates, uniformity, durability, and a uniform degree of

hardness and toughness, are desirable. Stone screenings contain too much dust for satisfactory use as concrete aggregate. They also make it more difficult to finish the pavement. Seven theories of designing concrete mixtures were discussed.

Discussing tests of finished pavements, Mr. Mattimore stated that three methods are in general use; (1) A compression test on specimens made and partially cured in the field; (2) a compression test on cores drilled from the finished pavement; and (3) a transverse beam test on specimens made and cured in the field. Although the prevailing practice has been to keep concrete pavements closed for three weeks, the indications are that it is better practice to vary the time according to the results of tests. Up to the present time the procedure for making the field transverse test has never been standardized so as to produce comparable results by different observers.

P. J. Freeman of the Allegheny County department of public works, in Pennsylvania, discussed the practical aspects of Mr. Mattimore's report. He believed that not enough attention has been paid to the weight of the bagged cement at the mill. In some cases observations show a difference of 13 per cent between the high and low weight. Careful consideration should be given the proposed plan of proportioning the cement by weight. With regard to the bulking of sand, it is not a difficult matter to determine the percentage of moisture in the field. The weighing and inundation methods seemed to be the simplest yet devised.

Referring to the committee's recommendations relative to the sampling of coarse aggregate, he differentiated between the purposes of the sampling. If it is desired to determine the average quality of coarse aggregate, say on a barge, then the suggested method is satisfactory, but where it is desired to determine whether one end of a pile is badly segregated, then a method other than that proposed by the committee would have to be used.

With reference to sampling, proportioning and design of concrete mixtures, Mr. Freeman believes that more attention should be given to prevention of segregation of aggregate. To accomplish this, flat rather than conical piles should be used.

Referring to the proposed method of proportioning concrete by combining definite weights of the several constituent materials, the speaker believes that nothing more elaborate is being advocated than what has been in use for years in the construction of bituminous pavements.

Mr. Freeman emphasized the urgency of placing wet burlap on the concrete as soon as possible for curing. He fears that too much time is being spent on finishing. Stating also that excessive checking is caused by too early belting, he believes there is a happy medium of time and that more research is needed concerning this factor.

Testing Finished Pavement.—Calling attention to the present methods of testing the finished pavement, he stated his belief that it is illogical to close pavements for a standard time of three weeks in July and November, because of the widely different weather conditions. Some of the concrete pavements in Allegheny County, laid in the summer, have been opened successfully in three days, while other projects, built late in the fall, have not been opened until the following spring. For the traffic in Allegheny County Mr. Freeman believes that a modulus of rupture of 500 pounds per square inch, as determined by the beam test, gives an ample factor of safety.

D. A. Abrams, acting as presiding officer at the morning session on December 2, introduced A. J. Brosseau, who spoke on highway finance. The speaker analyzed the aggregate Federal expenditures and showed the relation thereto of the Federal highway disbursements. The Federal road expenditures were shown to be less than 8 per cent of the entire rural highway bill. Mr. Brosseau believes that our national highway finance structure is sound, necessary, and profitable.

Use of Gas Tax on City Streets.—In discussing Mr. Brosseau's paper, Professor Agg called attention to a new problem that is arising in highway finance. His studies indicate that, in some instances, municipalities are requesting that a portion of the gasoline tax be prorated to them for the construction and maintenance of the city streets. The city argument is that their motor-vehicle users are paying for a large part of the cost of rural roads, for which they are not receiving an equitable return. Professor Agg pointed out that if the gasoline taxes are returned to the cities the tendency will be to dissipate the funds which are now being used through a central State agency to secure maximum results on the rural roads. In discusing this point, J. G. McKay, of the Bureau of Public Roads, presented some conclusive arguments. He stated that traffic surveys of the bureau indicate that 80 to 90 per cent of the rural-road traffic and the bulk of the heavy-truck traffic originate within city limits. It is, therefore, logical that the city motor-vehicle owners should bear the bulk of the cost of the rural roads. He also added that there is no reason why the rural land owner should pay for any considerable portion of the through trunk roads because land values in the strictly rural areas are not increased to a large extent by this kind of road development.

Highway Traffic.—G. E. Hamlin, of the Connecticut State Highway Commission, as chairman, introduced the individual reports of the committee on highway traffic. He stated that highways should be classified with respect to their weight-carrying capacity, and that there is an urgent need for establishing adequate rights of way in congested rural areas. Computations were presented showing that the maximum capacity of a single-lane road amounting to 1,969 motor vehicles per hour occurs at a speed of 22 miles. The maximum capacity of a two-lane road with mixed speeds is somewhat less than twice that of the single-lane road. He outlined the effect of overcrowding a two-lane road and showed the magnitude of the time losses at grade crossings and in small villages. The precautionary stop of a motor vehicle at a grade crossing was said to average seven and one-half to eight seconds. A comparison was made of the time consumed on by-pass or belt routes around centers of population, as contrasted with through roads. Forecasting the future development of traffic the speaker saw an increase in the use of six-wheel trucks.

J. G. McKay, of the Bureau of Public Roads, as a member of the committee, gave a description of the new traffic-flow recording device now being used by the bureau in the traffic studies in the Cleveland metropolitan area. An attempt is being made to determine the traffic capacity of various widths of roads as well as the preferential speed for various densities of traffic.

A. N. Johnson showed lantern slides of the airplane pictures taken during the traffic study on the Washington-Baltimore boulevard. The pictures were taken at an elevation of 3,600 ft. and showed a strip of land 2,000 ft. on each side of the road.

H. J. Kirk of the Ohio State Highway Department gave a description of a traffic speed recorder which had recently been manufactured by a firm in Dayton, Ohio. The variations in speed of a motor vehicle are shown by variation in the slope of a graph made upon paper mounted upon revolving cylinders. The device has been used on delivery wagons to determine if drivers are making the rounds on a regular schedule and may be useful in traffic flow studies.

Results of Traffic Studies.—Discussing the report of the committee on highway traffic, W. G. Sloan, State highway engineer of New Jersey, stated that traffic studies are vital to the solution of the highway transportation problem. Basing his remarks upon traffic surveys made in New Jersey, he estimates a 200 per cent increase in traffic in 1932, as compared with 1923. Traffic surveys and gasoline consumed indicate that the annual mileage traveled by automobiles is increasing more rapidly than the motor-vehicle registration. A graph prepared by the New Jersey department shows 1,600 vehicles as the maximum capacity of a single-traffic lane at 22 miles per hour, while the curve of the committee indicates 1,969 vehicles. The speaker em-

phasized the economic loss caused by the interruption to the flow of traffic at grade crossings in addition to the loss due to accidents and fatalities.

Selling Research to the Public.—Maurice Holland, director of the division of engineering and industrial research, gave an address on the subject of selling research to the public, or, as he expressed it, making the public research conscious. There are at present 1,000 research laboratories in the country and this is an increase of almost 100 per cent in six years. Stating that a man's success in business is in direct proportion to his ability to sell his services, he believes that until research can be translated into the language of the man on the street, we can not expect to obtain general attention. Lindbergh's flight was an example of the popularization of science, and today, as a result, 117 airplane factories in this country are running behind their production schedule.

The speaker said that the results of research must be made apparent and that proper showmanship is necessary to popularize the message. He referred to Pasteur as a master showman in reporting his studies to the French Academy, before whom he demonstrated the effects of living anthrax germs.

Speaking of the four mediums for reaching the public, he said that with the spoken word, in lecture form, only the attention of a few hundred people at best could be held. With articles written in trade journals 6,000 to 60,000 people could be reached. He mentioned the motion picture as an untired medium from a research standpoint, and added that one weekly news reel reaches 12,000,000. The speaker believes that radio the least expensive and most effective means of disseminating public information. One broadcasting station in New York City reaches four or five million people nightly.

Low-Cost Road Investigation.—At the afternoon session C. N. Conner, chairman of the committee on low-cost road improvement, gave a detailed study of the construction practices determined by field inspections in 23 States. The work of the committee has been financed by the American Road Builders' Association and T. Coleman du Pont. The purpose of the study is to assist those engaged in the construction of this type of road. Studies of typical cross-sections in 26 States were shown with lantern slides. The low-cost roads studied have an average traffic of 600 and a maximum of 1,500 per day. The survey has been limited to untreated surfaces costing less than $10,000 a mile and surface treatments costing less than $6,000 a mile. The report presented was a digest of the full report which contains 60,000 words.

H. J. Kirk, of the Ohio State Highway Department, followed with a discussion of untreated traffic-bound types of low-cost roads.

C. A. Hogentogler, of the Bureau of Public Roads, presented a report on subgrades and soils, indicating their relation to the low-cost road problem. The subgrade soil observer attempts to determine where rigid or flexible road surfaces may be laid. The surest subgrade treatment was believed to consist of a granular subbase compacted under traffic.

N. S. Anderson, of the South Carolina State Highway Department, described the surface treatment of main highways with topsoil and selected earth. For bituminous surface treatment, the base should be sufficiently porous to permit the tar prime coat to penetrate one-fourth inch. Excessive mica in the material makes the base unstable.

Cost of Untreated Surfaces.—W. R. Neel, of the Georgia State Highway Department, described untreated surfaces of sand-clay, chert, and gravel. He discussed the materials, methods of construction, cost of construction and maintenance, serviceability and salvage value. The average cost of sand-clay roads in Georgia is $1.650 a mile and the average annual maintenance costs $170 per mile. These roads are serviceable for 400 vehicles a day or less. For this amount of traffic the annual loss of surfacing material is one inch of depth. The sand-clay road is of great value as the first step in stage construction for stabilizing subgrades.

Chert construction costs up to $7,000 a mile and carries up to 1,000 vehicles a day. The average annual loss in depth is one-half inch.

On gravel roads, the traffic should not exceed 1,000 vehicles a day. The average annual maintenance cost is $200 a mile. The average annual loss in depth is ¾ in.

The Georgia State Highway Department has co-operated with Doctor Strahan, of the University of Georgia, in an extensive study of low-cost roads which has recently been completed.

J. T. Pauls, of the Bureau of Public Roads, presented a report on mixed-in-place surfaces, using local topsoil and gravel aggregates and tar or asphalt. The maintenence costs of untreated roads are excessive for a traffic greater than four to five hundred vehicles a day and resort is being had to various bituminous materials. Preliminary studies have been carried on in several States. To obtain good results with this type, correct maintenance is as necessary as first-class construction.

Mixed-in-Place Surface.—V. R. Burton, of Michigan, presented a paper on mixed-in-place surfaces of stone or gravel and fuel oil, prepared by C. L. McKesson, of the California State Highway Commission. This paper was in the nature of a discussion of Mr. Conner's paper. Mr. McKesson believes that untreated rock and gravel surfaces can not be justifiably termed low-cost roads when all the dependent costs are considered, such as maintenance, replacement, interest on first cost, excessive tire wear, motor-vehicle depreciation, and gasoline expenditures. Bituminous treatments according to recent California and Oregon practice are believed to so reduce these costs that the resulting surface might be classed as a low-cost road. Mr. McKesson had just returned from a trip abroad and it is his impression that European highway engineers agree that untreated gravel or stone roads are no longer economical.

B. E. Gray, of the West Virginia State Road Commission, illustrated his paper on the use of soft stone in the construction of puddle macadam with a number of lantern slides. The construction of the soft sandstone surfaces was said to range in cost between water-bound and penetration macadam. The annual maintenance costs, for traffic not exceeding 800 vehicles per day, does not exceed $200 to $300 per mile.

W. A. Van Duzer, of the Pennsylvania State Highway Department, discussed maintenance methods and equipment, referring to the maintenance organization of his State.

Traffic Capacity and Service of Low Cost Roads.—J. G. McKay, chief of the division of highway transportation and economics of the Bureau of Public Roads, presented a paper on traffic capacity and service of low-cost roads. He stated that the life costs of low, middle, and high-class surfaces must be determined before an intelligent selection of types may be made. Referring to the large mileage of low-type roads in the country, he stated that traffic studies of the bureau indicate that even in the densely populated State of Ohio, 70 per cent of the State highway system carries less than 600 vehicles a day. In both Pennsylvania and Vermont, 70 per cent of the primary road systems show an average daily traffic of 600 vehicles or less. With regard to the maximum wheel loads of trucks, the speaker believes that a 7,500-lb. load per wheel will cover the maximum loading on 75 per cent of the State systems. Less than 1 per cent of the Pennsylvania State highway system carries wheel loads in excess of 9,000-lb.

Grade Crossing Accidents.—The December issue of California Highways and Public Works reports an interesting analysis of grade crossing accidents on twenty-four railroads in California for the period from January 1, 1925 to May 10, 1927. The analysis was made by the State Railroad Commission. The 2,251 accidents analyzed were as follows: On crossings protected by crossing signs, 946; by wigwags, 654; by human flagmen, 290; by overhead crossing signs, 293; by gates, 34; by crossing bells, 34. These 2,251 accidents resulted in 297 persons being killed and 1,054 injured. Porperty damage only occurred in 1,360 accidents.

Recent Developments in Highway Research

Paper Presented at Annual Meeting of American Association of State Highway Officials

By V. L. GLOVER
Engineer of Materials, Illinois Division of Highways

THE field of highway research work throughout the United States has grown to such an extent that it is practically impossible for any one man to discuss all of the recent developments. A large number of agencies are involved, and there is a noticeable lack of information on specific projects. Research surveys published show that the scope of the work includes practically every phase of highway work; one recent survey listed almost 100 separate investigations under way. The subjects listed under these surveys indicate that practically all of the agencies work separately, and that many identical phases are the subject of simultaneous investigations. It is also evident that comparatively few of the investigations concluded are ever put into such form as to make them available for others.

This paper, therefore, will be confined to recent developments in the work which Illinois has been doing, touching on three subjects which it is believed will be of interest to other states.

Field Control of Quality of Concrete

The subject of field control of quality of concrete is perhaps receiving as much attention at this time as any other single subject. Illinois started an investigation late in 1925, referred to in one or two recent surveys as the "Void-Bulkmeter" investigation, which led to a change in our field methods during the present year.

We proportioned by volume, and we were not satisfied with the results which we were securing. Apparatus was constructed which permitted the measurement of both loose and compacted volumes of entire batches of material, the determination of voids, settlement due to haul, and the uniformity of gradation in the different batches. Essentially it consisted of a graduated cylindrical receptacle, mounted on a trailer, taking the power necessary for its operation from the truck; it was fitted with sieving apparatus and means of performing inundation tests and determining voids in the material. A view of the device is shown in Fig. 1.

Fig. 1—Device Used in Void-Bulkmeter Investigations

How the Tests Were Made.—To insure representative results, 37 road jobs located in all parts of the state were visited. The method of procedure was as follows: For the coarse aggregate a full batch of material was taken directly from the measuring hopper, initial volume readings taken, and the truck driven over an ordinary dirt road at a speed of about 15 miles per hour to obtain the settlement which might occur under field conditions of transportation. The volume was read at the end of each mile until six miles had been covered. The percentage of voids was determined, a sieve analysis made, the amount of moisture determined, and the weight per cubic foot computed. Tests of the fine aggregate were conducted in a similar manner, except that an inundation test was made. The results of the inundation test, however, were in error due to the method of manipulation, and did not show all of the bulking present. Laboratory tests were made which included a determination of the voids in the material and the strength and yield of the concrete made from it.

Results of This Test.—From this test we gained, together with other information, the following facts:

1. That under practical field conditions both stone and gravel coarse aggregates are subject to shrinkage, the average for 18 gravel jobs being 5.5 per cent and for 14 stone jobs 7.6 per cent.

2. That the percentage of moisture contained in the sand on the 32 jobs averaged a little over 3 per cent.

3. That the bulking in the sand due to moisture content caused an undersanded mix, affecting both the workability and yield of the concrete.

4. That the actual field proportions when reduced to compacted volumes averaged 1:1.88:3.46 instead of 1:2:3.5, the nominal mix.

The field proportions of 1:1.88:3.46 showed two things: first, that the mix was undersanded, and, second, that it was common practice to add additional coarse aggregate to regulate the cement factor. The shortage of sand was even greater than indicated by the field proportions, because, as mentioned, the inundation method employed was not correct and did not show all of the bulking present.

Bulking of Sands.—During the winter of 1926 the investigation of bulking of sands was continued by examination of 62 different sands from as many different sources supplying our work. From this study we learned that:

1. With the presence of even a slight amount of moisture in the sand, the actual volume of mineral aggregate in any unit will be reduced.

2. The unit weight will decrease, or the bulking will become greater, as the percentage of water increases from 0 per cent to 5 or 6 per cent by weight.

3. At the point of maximum bulking, which occurs with a moisture content of between 5 and 6 per cent, the unit weight will be approximately 20 per cent below the unit weight of dry sand determined by the A. S. T. M. method and 26 per cent below the unit weight of inundated sand.

4. For the 62 sands studied the amount of bulking, or reduction in weight, can be measured by the ratio

of loose volumes to inundated volumes with a degree of accuracy sufficient for field use.

5. That for these sands the average corrections for bulking for the various percentages of moisture are:

Per Cent of Moisture	2	3	4	5	6	7
Aver. Bulking Correction	1.213	1.24	1.251	1.259	1.256	1.256

That is, to obtain a unit volume of inundated sand, it would be necessary to multiply the unit volume of loose sand containing say, 2 per cent moisture by the factor 1.213; or, sand containing 2 per cent moisture would occupy 1.213 times as much space as when in the inundated condition.

Changes in Method of Proportioning.—With the information from these two investigations available, supplemented by other laboratory work, we made the following changes in our method of field proportioning:

1. An arbitrary correction of 15 per cent was made to correct for bulking of sand due to moisture content.

2. An arbitrary correction of 6 per cent was made to correct for shrinkage of gravel coarse aggregate and 8 per cent for stone coarse aggregate.

These percentages are added to the nominal loose measurements of the aggregates, so that our proportions are 1:2.3:3.71 and 1:2.3:3.78 instead of 1:2:3½.

These corrections were made with the full realization that no arbitrary correction can be made which will fit all conditions. They are average corrections intended only to mitigate the difficulties caused by several variables, and are low enough to be conservative under all conditions.

The indications from this year's work are that we are getting more workable concrete, better finish, are using less water, and are saving cement without sacrificing strength.

Multiple Loads.—There has been for several years an insistent demand on the part of motor truck manufacturers and users for legislation which would permit heavier gross loads on paved highways. Illinois has been reluctant to accede to such demands, in spite of the fact that several states have for some time permitted heavier gross loads than 24,000 lb.—our legal maximum. An investigation was started late in 1926 to determine what changes might be permitted with safety.

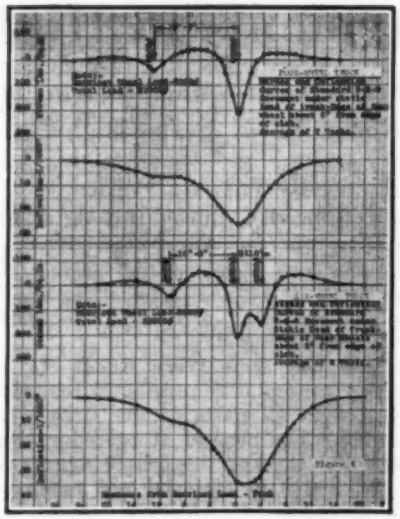


Fig. 4

The Illinois standard 9 in.-6 in.-9 in. concrete pavement is designed in accordance with principles demonstrated to be safe under actual service conditions by the results of the Bates Experimental Road. It will carry a maximum axle load of 16,000 lb. with a reasonable factor of safety, but any increase of this axle load would reduce this factor and introduce an element tending to hasten the destruction of the pavement. Illinois has over 1,250 miles of various designs of concrete pavement built prior to 1922, when the Bates type was adopted, which, when analyzed according to present day knowledge, have safety factors under an 8,000 lb. wheel load varying from 1.00 to 1.89, with over half of it having safety factors of 1.5 or less. Increasing the wheel load from 8,000 lb. to 9,000 lb. would jeopardize an investment in the older types of pavement reaching many millions of dollars, and would reduce the safety factor of the newer type to a figure considerably below 2.00. The older types of pavement are still giving good service with a reasonable maintenance cost, and for this reason cannot be considered as obsolescent.

Tests of 6-Wheel Truck Loads.—The problem, therefore, resolved itself into finding some way to permit greater gross loads without exceeding the 16,000 axle load, and without exceeding the stresses produced in the pavement by one 16,000 lb. axle load. The use of 6-wheel trucks appeared to be a solution, and a series of tests was undertaken, using at first static loads applied to the pavement with specially constructed loading apparatus. The effect of two 8,000 lb. static loads, such as might be encountered in the use of 6-wheel trucks, applied at various spacings near the edge of the pavement, were compared with a single static load of 8,000 lb., the latter corresponding to the wheel load of a 4-wheel truck. Stress measurements were made along the edge of the pavement with a Berry Strain gage provided with a $\frac{1}{10{,}000}$ in. Ames dial. The results, given graphically in Fig. 2, show that only for longitudinal spacings of less than 2 ft. do the stresses exceed those due to a single load of 8,000 lb. In all other cases the stresses are slightly smaller. Fig. 2 shows that the stresses pass from compression to tension at a point about 2 ft. 4 in. from the load.

In making this test the center of the applied loads was at a point 7 in. from the edge of the pavement, while the stresses were measured 2 in. from the edge. For this reason the measured stresses may not necessarily be the maximum stresses that may occur. They do, however, show a true comparison between the effect of the single load and the two loads applied at the various longitudinal spacings.

Tests were also made with heavier

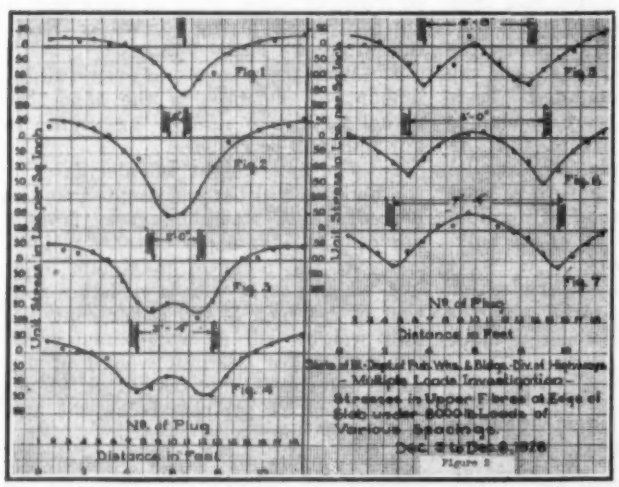


Fig. 2—Stresses in Upper Fibres of Edges of Slab Under 8,000 Lb. Loads of Various Spacings

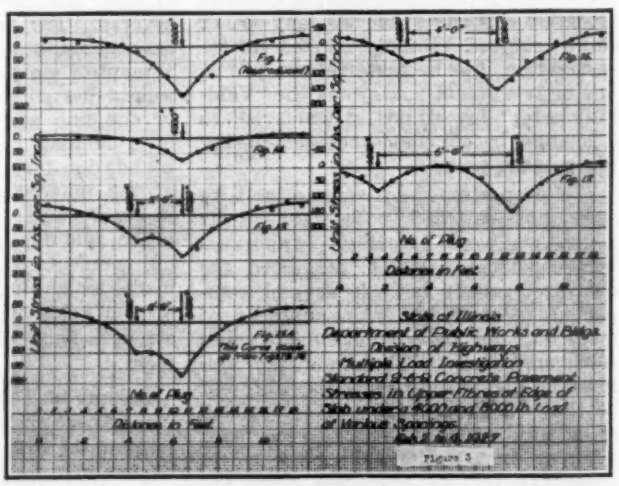


Fig. 3—Standard 9-6-9 Concrete Pavement Stresses in Upper Fibres of Edge of Slab Under 4,000 and 8,000 Lb. Load of Various Spacings

loads which indicated that the spacing of the loads should be kept greater than 3 ft. to take care of the most extreme subgrade in the spring.

In addition to these tests, another series was undertaken to compare the effect of two unequal loads—4,000 and 8,000 lb.—applied simultaneously at various spacings, with the effect of a single 8,000 lb. load. The results, given in Fig. 3, show that the stresses produced by two unequal loads do not exceed those produced by the greatest load alone, provided the loads are spaced at least 3 ft. from each other.

Comparison of 6-Wheel and 4-Wheel Trucks.—The next step was to compare a 6-wheel truck and a 4-wheel truck under actual conditions to confirm, as far as possible, the results of the previous tests.

It was intended that all wheel loads except those on the front wheels should be 8,000 lb. but because of the design of the 6-wheel truck used, it was impossible to obtain this condition of loading due to the fact that when each wheel on the intermediate axle was loaded with 8,000 lb., the wheels on the rear axle each carried a load of 6,000 lb. The load on each rear wheel of the 4-wheel truck was 8,000 lb. The two rear axles of the 6-wheel truck were spaced 46 in. apart.

All stresses and deflections were measured with the rear wheels of each truck about 2 in. from the edge of the pavement. A typical comparison of the static stresses and deflections produced by each truck is shown in Fig. 4.

The deflections caused by moving loads were recorded, but no actual stress measurements were made; however, since the deflection is proportional to the stress produced as long as the same system of loading is present on the pavement, the stresses caused by the moving loads were computed on this basis.

The results of these tests show that both the deflections and stresses due to a load moving at an ordinary speed are about 90 per cent of those caused by the same load applied statically, and that the maximum stress caused by each type of truck is practically the same.

Truck Impact Tests.—A number of impact tests were also made with each truck, the results of which showed that the effect of impact due to the 4-wheel truck is considerably greater than that caused by the 6-wheel truck. However, for pavements constructed so that surface variations do not exceed ¼ in. from a true surface, the effect of impact due to an 8,000 lb. load is not believed to be serious.

In addition to these tests, stresses were computed using the formulas developed by Prof. Westergaard in his "Stresses in Concrete Pavements Computed by Theoretical Analysis," published in "Public Roads," April, 1926, and compared with experimental data obtained during the Bates Experimental Road tests. It was found that the results obtained by these two methods checked very closely.

In substance, Prof. Westergaard also states in that part of his analysis comparing the effect of 4-wheel and 6-wheel trucks, that where a pavement is loaded in a manner similar to the loading of a 6-wheel truck, the main part of the stress produced under any wheel load at a given point is due to the wheel load over that point. In other words, that the stress produced under one of the four rear wheels of a 6-wheel truck

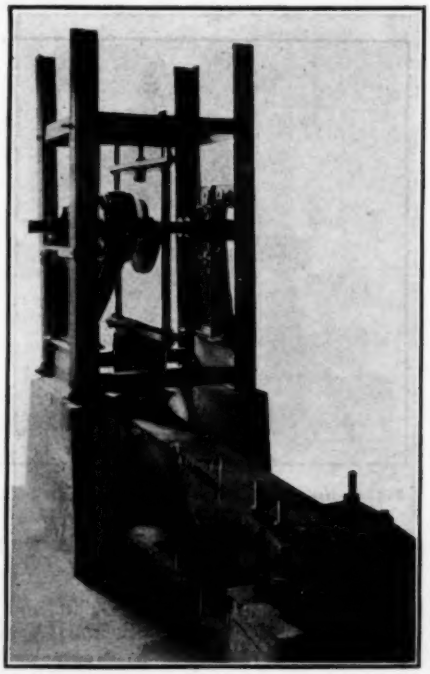


Fig. 5—Machine Used for Applying Impact Loads

is caused principally by the load on that wheel, and that this stress is slightly reduced by the presence of the three remaining wheels. Similar results were found during our own tests.

The Bureau of Public Roads conducted extensive tests on 6-wheel trucks, the results of which were published in "Public Roads," October, 1925. The following is an extract from that report. "The tests show also that the stress produced in the pavement by 6-wheel vehicles is a function of the load on the wheels and not of the axle spacings. This seems to be true for all spacings of the rear axles greater than 3 ft., there being some indication that when the wheels are closer together than 36 in., the stress produced in the pavement may be increased.

"It is also shown that under 6-wheel as well as 4-wheel trucks the maximum tensile stress occurs in the bottom of the slab, regardless of the axle spacing. Even though there is counterflexure of the pavement between the wheels, the tension developed in the top of the slab is of less magnitude than the tension developed in the bottom of the slab directly under the wheels. This latter tension, therefore, is the critical stress for 6-wheel as well as 4-wheel vehicles."

These conclusions are in accord with our own findings.

Conclusions from Multiple Load Tests.—In view of the results obtained in all of the above tests we felt justified in drawing the following conclusions:

1. That the present standard 9 in.-6 in.-9 in. pavement which is designed to carry one rear axle load of 16,000 lb., will carry an additional 16,000 lb. rear axle load without any greater detrimental effect than that caused by a single axle load of 16,000 lb., provided that the spacing of the axles is kept greater than 36 in.

2. That under a system of unequal rear axle loads, the maximum stresses produced in the pavement are no greater than the maximum stress produced by a single rear axle load of the same magnitude as the greatest axle load in the system of unequal loads, provided that the spacing of the axles is kept greater than 36 in.

3. That the stresses produced in the pavement by loads moving at ordinary speeds, disregarding any effect due to impact and sudden application of the load when passing across transverse joints and cracks, are about 90 per cent of those caused by the same loads applied statically.

4. That the maximum stress caused by a truck having two rear axles spaced not less than 36 in. apart, is no greater than the maximum stress produced by the single rear axle load of a 4-wheel truck provided the individual rear axle loads on the 6-wheel truck do not exceed the rear axle load on the 4-wheel truck.

5. That the effect of impact caused by a 6-wheel truck, due to irregularities in the pavement surface, is not as great as that caused by a 4-wheel truck, provided the individual rear axle loads on the 6-wheel truck do not exceed the rear axle load on the 4-wheel truck.

6. That the total gross load on a vehicle may be increased by providing an additional axle, if the spacing between the two rear axles is kept greater than 36 in. and if the load on any individual axle does not exceed 16,000 lb.

As a result of this investigation and the other data mentioned, the highway department felt justified in concurring in legislation passed by the last general assembly permitting the use of self-propelled 6-wheel trucks provided the gross weight, including the weight of the vehicle and the maximum load, does not exceed 40,000 lb., and provided that

axle spacing shall not be less than 40 in. center to center.

The use of the 6-wheel truck provides the means whereby the heavy hauling problem in the great metropolitan areas can be relieved to some extent at least and still provide protection for the millions of dollars which the public has invested in roads.

Suitability of Various Grades of Steel for Reinforcing.—During 1925 an investigation was conducted to determine the suitability of various grades of steel for reinforcing. Prior to this time only structural and intermediate grades were permitted, but the results of this investigation were such that during 1926 hard grade new billet and rerolled rail steel were included as permissible materials for pavement and bridge work, thereby opening up new sources of supply and materially reducing the cost. During 1927, after a year's experience with it, a further investigation was undertaken to settle several points which arose in connection with its use and to extend the scope of the first investigation, which included mostly sizes ⅞ in. and less in diameter. The last investigation emphasized especially the larger size bars, that is, above ⅞ in. in diameter. While the results have not been placed in report form, several phases of the work may be of interest, especially the methods used in making the tests.

Impact Test of Bars Embedded in Concrete.—One of the most important tests was an impact test on bars embedded in concrete. This test was designed to approximate the conditions existing at a pavement construction joint or transverse crack at right angles to the longitudinal bar, subject to repeated loads due to traffic.

Concrete beams were constructed, at the center of which were embedded the bars to be tested. The bar traversed an open joint 18 in. from the end of the beam. Fig. 5 shows the machine used for applying the impact loads on the specimen. It consisted of a box frame built of I-beams and angles which held the mechanism for raising and releasing the weight. The weight was a machined steel forging securely bolted to the lower plate of a frame which slid on two vertical guides. A large cam, driven by a power pulley on the same shaft, raised and dropped the weight through a vertical distance regulated by adjusting the roller on the upper plate of the frame to which the weight was bolted. The cam was designed to furnish instant release and to drop the weight as a free falling body. The effective weight, as determined by actual test, was 185 lb.

After the concrete beams had aged for 28 days, they were subjected to the impact test. All of the beams were tested to failure, and the results in general verify the findings in the former investigation, that is, that the ¾ in. and ⅞ in. hard grade new billet and rerolled rail steel bars showed the greatest resistance to stresses imposed under repeated impact loads.

Bend-Pull Test.—A bend-pull test was designed to reveal any tendency toward incipient fracture or other structural weakness in cold bending. It consisted of subjecting the bars to a 90 deg. cold bend, and then testing them in tension while being held over a pin equal in diameter to three times the diameter of the bar. Fig. 6 shows the special machine head used in this test with one side plate removed to show the arrangement by which the bar, after being bent, was held over the pin while one end was loaded.

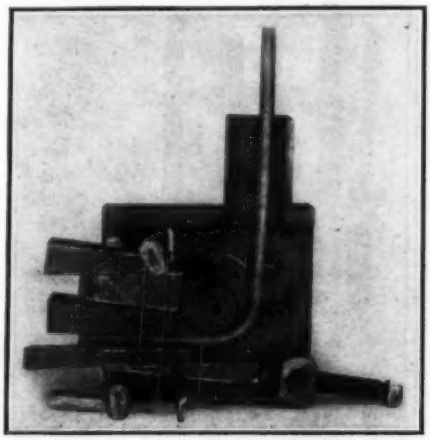


Fig. 6—Special Machine Used in Bend-Pull Test

This test included ¾ in., ⅞ in. and 1 in. round bars, and 1⅛ in. and 1¼ in. square bars of rerolled rail steel, intermediate and hard grade new billet. The results indicate that the ¾ in. and ⅞ in. bars will not be affected by the preliminary bending regardless of the grade of steel, whereas the 1 in. round and the 1⅛ in. and 1¼ in. square bars in all grades of steel had a tendency to fail at the bend with a corresponding loss in tensile strength.

A special bend-pull test was designed to determine the effect of cold bending on the tensile strength of various grades of steel. The specimens were bent cold and then straightened and tested in tension. The specimens were bent in the usual manner, the bending head moving downward against the bar, which was supported on two rolls. After bending, they were straightened in the testing machine by placing the bar in a channel formed by two steel plates and operating the moveable head downward. Fig. 7 shows this device.

This test included ¾ in., ⅞ in. and 1 in. round and 1⅛ in. and 1¼ in. square bars from rerolled rail steel, hard grade new billet, and intermediate new billet.

In general, the results indicate that the ¾ in. and ⅞ in. bars in all grades will withstand this test successfully, but that the 1 in., 1⅛ in. and 1¼ in. bars in all grades will fail, the number of failures varying with the grade of steel.

Special Impact Test on Bent Bars.—As a further test of possible weakness produced by the cold bending of steel bars, a special impact test on bent bars was devised. The bars were first bent to an angle of 90 deg., and one leg of the angle placed vertically in a support so that the other leg extended horizontally as a cantilever. A constant weight was dropped through a known distance to the horizontal leg, and the loading was repeated until the bar was either bent to such an angle that the blow was no longer effective or until breakage occurred. Fig. 8 shows the special machine used in this test. It applied the blow mechanically, recorded the number of blows, and charted the rate of settlement of the bar and the rebound of the falling weight. The charting of the rebound is especially important where steel of various grades is being tested because the degree of bend under each blow greatly affects the rebound of the falling weight. Apparently low tensile strength steel absorbs some of the blow due to bending, whereas high tensile strength steel will not bend, thus causing a succession of impact blows of decreasing magnitude after each main blow. The height of fall of the weight was increased or decreased in proportion to the cross-sectional area of the bar under test so that a direct comparison could be made between the various sized bars. It was thought that any defect caused by cold bending would cause failure of the bar in this test, or would at least exaggerate the defect to such an extent that it would be easily visible. The test included ¾ in., ⅞ in. and 1 in. round and 1⅛ in. and 1¼ in. square bars from rerolled rail steel, hard grade new billet and intermediate new billet.

For bars over ⅞ in. in diameter, this test brought out one feature that is especially noteworthy, that is, the relation of the size, shape and trend of the deformations on the surface of the bar to the location of the failure. There are indications that there is a definite relation between the deformation and the failure of the bar, but this phase of the investigation has not yet been studied sufficiently to give any definite conclusions. Bond tests have also been made on some of the new type deformed bars to determine the effect of the deformation on the bond.

An impact bend test on straight bars was designed to detect the brittleness of the higher tensile strength steel bars, and to determine the effect of impact bending on bars in which the elongation caused by the bending is not confined to the section adjacent to the bend only. The bars were tested in the same impact machine used for testing the bent

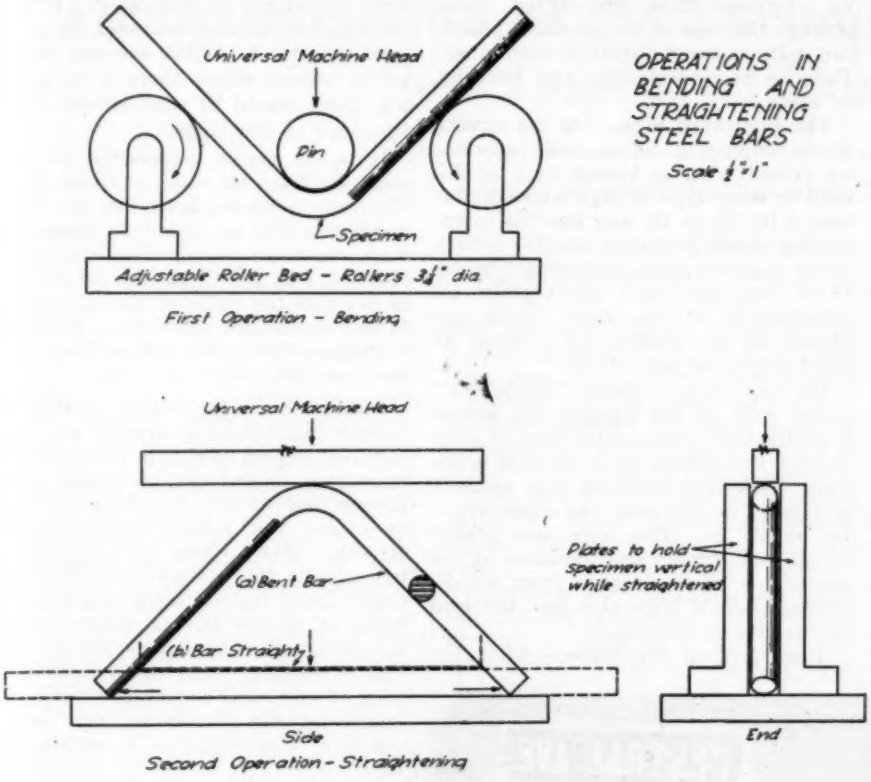


Fig. 7.—Device Used in Cold Bending Tests

bars. They were placed in a horizontal position so that the impact blow was received on the end of a 12-in. cantilever extension while the bar rested free on a fulcrum. The opposite end of the bar was securely fastened 24 in. from the fulcrum. This arrangement permitted the bar to bend freely over the fulcrum as each successive blow fell, and the elongation due to bending was free to take place over a distance of 12 in. on each side of the bend. The fixed end of the bar was so arranged that as the bar bent from the horizontal to such a position that the impact blow was no longer effective, the fixed end was lowered and the bar rotated at the fulcrum to raise the end and maintain that portion of the bar between the fulcrum and the falling weight in a horizontal position. Graphical records were also taken of this test. Only the 1 in., 1⅛ in. and 1¼ in. bars from rerolled rail steel, hard grade new billet and intermediate billet were included in this test. The type, size and trend of the deformations had an apparent effect on this test, but the exact relation of these variables has not been determined.

This investigation included 689 individual tests. Some of the tests, such as impact of embedded bars in concrete or impact on bent or straight bars, took from one to three days to complete. There are approximately 300 graphical representations of the action of the bars under the respective tests.

What the Tests Indicate.—The results of the test indicate that:

1. The tests on bars up to and including ⅞ in. in diameter verify the conclusions reached in the first investigation that intermediate and hard grade new billet, and rerolled rail steel may be safely used in pavements and bridge construction.

2. The tests on the 1 in., 1⅛ in. and 1¼ in. bars in intermediate and hard grade new billet, and rerolled rail steel did not withstand the special tests as satisfactorily as the sizes below ⅞ in. and there is doubt as to the advisability of their use where bent bars in these sizes are required.

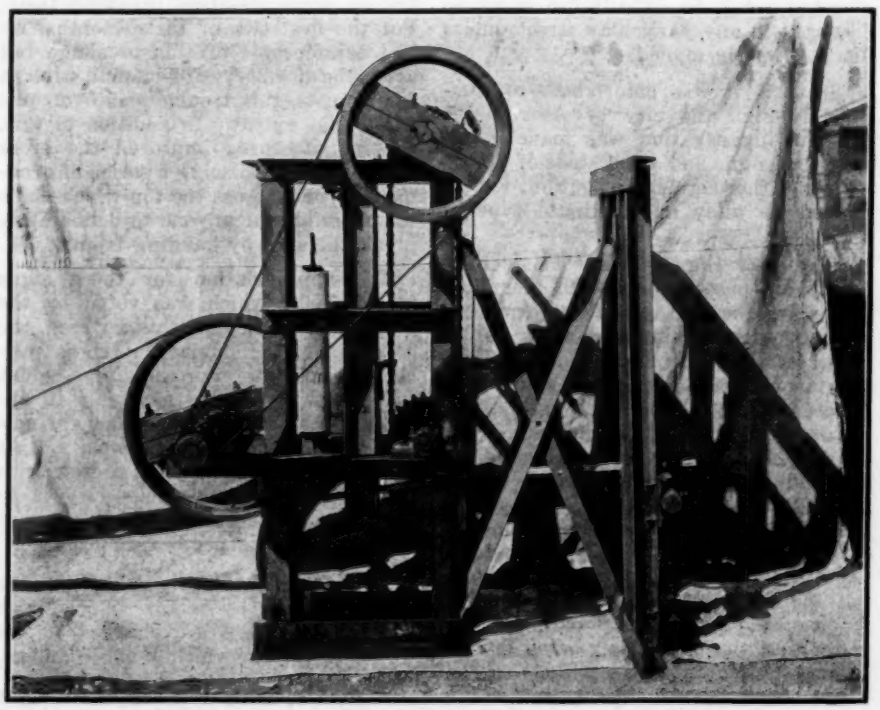


Fig. 8.—Special Machine Used in Impact Test on Bent Bars

"Drive in and Drive Out" Ditches

Advantage is being taken in New Mexico of a type of road construction said to have been originated in Oklahoma by Cyrus S. Avery, and termed by him as the "drive in and drive out highway."

There are many miles of mesa and prairie located highway in the state upon which it will be impossible to build Federal Aid type of highway for many years. Upon these highways the state has built and is constantly rebuilding a grader type of construction known as the "mesa type." To make these mesa roads safe for motorists the deep ditches are being filled up and a wide, shallow ditch substituted,—a "drive in and drive out" ditch. That is a ditch such that if a motorist is forced into it or accidently drives into it, he will not be precipitated over the landscape with his car, but can with ordinary quick handling of his car, pull over the ditch and out onto the mesa or more often guide his car back into the road again without mishap.

This type is being built in the regrading operations between Santa Fe and Albuquerque and elsewhere with excellent results. As rapidly as these mesa state roads are regarded the "drive in and drive out" method of construction will replace the old deeper ditch type.

Street Signs at Albany, N. Y.

New System Described in Paper Before International System of Street Sanitation Officials

By LESTER W. HERZOG
Commissioner of Public Works, Albany, N. Y.

A COMMUNITY, in signing its streets, should give thought to ornamentation and durability rather than to the first cost. For many years the city of Albany was inadequately signed. At one time signs were placed on the corner buildings but in many cases the buildings were torn down and repainted and the signs never replaced. When new streets were built, no signs were erected. This was particularly confusing as it is mainly in the newer sections of a city where signs are mostly needed.

We can all recall in our several cities certain sections which are as familiar to us as our own homes. We know the names of all the streets in these particular sections and just where they are located yet it is difficult for us to go directly to any particular street unless it is properly signed.

The Boulevard Type of Sign Has the Intersecting Street in Smaller Letters

In 1926 it was determined to completely sign the city of Albany. A careful investigation was made of all types of signs and at all kinds of prices. After a thorough investigation, we selected an alloy of aluminum type of sign.

The New Sign.—This consists of a cast iron post covered with aluminum alloy and the sign itself is an ornamental one with an aluminum alloy border with letters of the same material. Each plate on the cross type of sign measures 4 in. by 20 in. These signs are placed on posts 11 ft. in length and projecting 8 ft. from the surface of the ground, erected on diagonal corners, only two poles being placed at each intersection. Each pole has upon it a sign carrying the main street and at right angles to it, a sign with the name of the cross street. These are set in a concrete base and we found by experience that the poles after being erected were subject to being pulled out before concrete was entirely set and in some cases after the concrete had set. To overcome this, we drilled holes through the base of the post and placed two bolts at right angles to each other. This, we found held the sign securely in place.

The Boulevard Sign.—On the streets where boulevard lights were erected, we placed what is known as a boulevard or wing type of sign which measures 5 in. by 24 in. and has the intersecting street placed in smaller letters on an opposite plate measuring 3 in. by 18 in. over the main street plate, all embodied in the one sign. These are placed on the electric light poles at right angles to each other.

On our main street "State St." which runs to the Capitol, we placed a particularly ornamental type of sign having the letters in a vertical position. This sign comes in four sections and bolts on the pole and measures 5 in. by 24 in. This sign was placed on all four corners and the name of the street one is on, is seen from all directions. This sign also has the seal of the city on the top.

Protection of the Signs.—After the installation of these signs, we found considerable trouble with boys climbing the poles and hanging from the signs and in many instances breaking them. For the first two or three months, we had considerable of this breakage but after the novelty wore off and after a few arrests, this trouble was overcome to a great extent. In addition to this, the manufacturer improved the cross type of sign by placing a series of ornamental teeth across the top which made it impossible for anyone to deliberately break the sign by hanging from it.

The appropriation for these signs was $50,000, which was voted by the common council and this covered the entire city, the number of signs purchased being approximately 1,800. Later it was deemed advisable to appropriate an additional $15,000 for new signs, replacements and repairs. At the present time, we have a crew with a small truck whose sole duty is to take care of these signs and see that they are kept in perfect condition.

We often have signs which are knocked down by motor vehicles and the cost of these are charged to the owner of the car which did the damage.

In the repaving of streets, the signs are of course removed and replaced after the street is completed. It has not been our custom, however, to place signs on streets which are not paved as we believe where there is no curbing, there would be considerable damage done to the signs.

It is, of course, impossible to estimate the financial value of these signs. We have, however, been told by many merchants that an enormous amount of time was saved in deliveries after their erection. I do not think it is far fetched to say that the value of the time saved in deliveries has more than paid for the signs during the period they have been erected.

Street Numbering.—This question of "signs" undoubtedly brings to mind another subject which is becoming of increasing importance and that is the proper designation of streets by numbers and the proper numbering of streets. Many cities are taking the initiative in this matter and I think the time is not far off when the business value of having streets designated by numbers will overcome the sentimental side of naming streets after noted persons or historical events or with family names of the particular real estate operator who opens up a certain section.

With the proper designating of streets by numbers will follow the scientific numbering of houses. I understand some cities have already taken this forward step and the numbers on each block corresponds to the number of the crossing avenue so that knowing the house number one can immediately determine that it is between two certain avenues.

Culvert End Walls to be Removed in Wisconsin

As a result of numerous accidents the Wisconsin Highway Commission has directed the removal of culvert end walls on the state trunk highway system within the next two years. An extract from the letter to the division engineers follows:

"Two or three of the divisions have done quite a little work in removing culvert end walls. We refer to those end walls which were built some few years ago and which now constitute one of the most serious hazards which we have along our highways. We would suggest that you give this matter considerable thought and if possible arrange a program whereby we can eliminate practically all of these end walls within the next two or three years.

"In a great many cases you will find that it is not necessary to extend the culvert. All you have to do is use some care in removing the old end walls. In other cases you may find it necessary to extend the culvert for 3 or more feet on either end. This can be done very easily by inserting a short section of corrugated pipe made up special for this purpose in such a manner as to fit the square opening in the culvert.

"If you have any particularly short culverts on your main traveled roads we would like to suggest that you give this matter your serious consideration and arrange for the removal of the head walls early next season. We would also like to pass on to you the suggestion made by one of our county highway commissioners to the effect that whenever you start to remove the culvert head walls on any particular highway that you go clear through on the highway from one point to the next at least."

An Investigation of the Various Types of Low Cost Improved Roads

Summary of Report Presented Dec. 2 at Annual Meeting of Highway Research Board

By C. N. CONNER
Chairman, Committee Low Cost Roads, Highway Research Board

THE investigation was conducted more in the nature of a survey of the low cost road situation than as a detailed and scrutinizing research. Within a few years many have constructed and are maintaining thousands of miles of low cost roads. Many of these roads furnish continuous service between objectives. Over them the public is traveling in safety and comfort, and at high rates of speed. This has been made possible by extensive use of local materials and intelligent maintenance. The successful low cost surface is a light traffic road, carrying less than 1,500 vehicles per day as a maximum with an average of 600 or less. This may be mixed traffic with a fair percentage of the light trucks and an occasional heavy truck.

The survey was limited in general to untreated surfaces which cost less. than $10,000 per mile, and to surface treatments and surface courses which cost less than $6,000 per mile. It was advisable to investigate other types whose cost exceeded these amounts. This was done on some which had been successful under particular local conditions, on others to show their relative position in cost and service compared with lower cost types.

MATERIALS

For clarity and brevity two general classifications of surfaces are made—untreated surfaces and treated surfaces.

Materials for Untreated Surfaces.—The predominating surfacing materials are gravel, sand clay, hard and soft stone, slag and lime rock. There are also miscellaneous materials such as shell, volcanic cinders and stone screenings.

Sand clays are used principally in the southern states. According to Dr. Strahan suitable sand clays should contain, clay from 12 to 18 per cent, silt 5 to 15 per cent, total sand 65 to 80 per cent, and sand above No. 60 sieve 45 to 60 per cent.

Gravels of various quality and gradation are used in nearly every state. Nearly all specifications require that gravel shall be hard and durable that it shall all pass the 1½ in. screen, or better still through the 1 in. screen; California requires all gravel to be crushed. Clay in gravel as a binder is used sparingly.

Lime rock, marl, caliche and similar materials make excellent bases, but poor wearing surfaces. Because they are soft and crush during construction, large sizes up to 3½ in. are permitted.

Crushed stone and crushed slag of a durable character are being used for surfacing in much the same manner as gravel construction in sizes through the 1½ in. and 1 in. screen, and smaller. Stone for water bound macadam or broken stone base is specified in larger sizes.

Materials for Surface Treatments and Surface Courses.—The principal binders or admixtures are asphalts, tars, calcium chloride, lime and Portland cement.

The principad aggregates are gravel, sand, stone or slag, and sand clay.

In the asphalt field the slower curing asphaltic oils are becoming less popular. Cut back asphaltic materials appear to be gaining in popularity.

Hot asphalt or hot tar as a second application in dual treatment work satisfies several state highway departments.

Premixed asphaltic surfaces are generally hot mixtures. Cut backs are being tried for mixed-in-place, premixed surfacing and cold penetration macadam. Cold tars for surface treatment and mixed-in-place types of surfacing are giving good service in several states.

A new type of premixed surfacing is a cold patch tar mixed with stone in a concrete mixer.

Bitumens are the most widely used binder in the low cost surfacing field.

Calcium chloride to lay dust and prevent loss of binder is used extensively. Sulphite liquors are not now used to any appreciable extent.

Natural rock asphalt has entered the field of low cost surfacing.

Portland cement with local sand or local fine gravel as an aggregate is a departure from former standards. The possibilities appear good for obtaining a serviceable pavement with these aggregates, provided expansion and contraction are properly controlled.

Hard crushed stone or dense hard slag are preferred to sand and gravel in dual treatment work of the penetration type.

Softer and more friable crushed stone when used for this purpose is specified in larger than customary sizes of hard stone.

There is a general preference for crushed materials in surface treatment work.

Clean gravel and clean coarse sand for this purpose on account of availability and comparatively low cost, are still a popular cover material.

Aggregates for mixed-in-place surfaces are generally those in the roadway surfacing itself. Examples are the work in Wisconsin, California, Indiana and the test road in South Carolina.

Work of a similar character as done in Tennessee and Pennsylvania require new matrials as aggregate, for the bituminous surface.

In this type of construction cold asphalt or tar are used as binder. The aggregate may be stone, slag, gravel, or sand clay.

Premixed surfaces are usually hot mixes of the standard type such as bituminous concrete. When used with local sand or gravel the costs have been reduced. Examples are the sand asphalt work in North Carolina, and the bituminous concrete on Cape Cod, Massachusetts.

Convenience in construction and possible economies in plant equipment and operation point with some favor to a premixed cold bituminous surfacing.

Cold penetration macadam is being built in the United States with cut back asphalt or tar and in Europe with emulsions.

CONSTRUCTION METHODS

Construction methods may be discussed for three general types of surfaces:

I. Untreated Surfaces.
II. Types Using Non-Bituminous Admixtures.
III. Bituminous Surface Treatments and Surface Courses.

UNTREATED SURFACES

Untreated surfaces are constructed by one of three principal methods:

1. Traffic bound, layer method.
2. Traffic bound, one course method.
3. Roller bound, one or two course method.

There are some variations in practice such as obtaining compaction by rolling in addition to that of traffic in both 1 and 2.

Traffic Bound, Layer Method.—The principal example of this on an extensive scale is the recent work in Ohio. It has been practiced also in other states.

The object is to first stabilize the raw, compacted subgrade by the addition of clean hard aggregates.

Blading and dragging keep the surface regular. Traffic does the compacting. New Aggregate is added periodically. This becomes bonded and keyed to that previously placed until a dense and regular surface is obtained. Compaction is thus secured from the bottom or subgrade in successive bonded layers.

The construction operations are simple and consist of hauling, dumping and spreading the aggregates. All of them are done by mechanical equipment. The same equipment is also used for maintenance.

Traffic Bound, Course Method.—This method is generally followed for the construction of selected soil, sand clay and one course gravel.

After the materials are dumped on the subgrade, the principal operations are mixing in place. This is accomplished by plowing, harrowing and blading. If rains are infrequent, sprinkling with water produces an increased density.

Traffic and hauling of surfacing material finally bring the surface down to a well compacted mass. It may be advisable to use a roller on materials which carry little or no binder. A heavy roller is successfully used on the lime rock bases of Florida which bind together readily.

Some surfaces built by this method are not smooth because the aggregates were dumped in piles and allowed to stand before being spread and harrowed.

Roller Bound, One or Two Course Method.—Water bound macadams using various aggregates come under this heading.

The method is primarily to spread a layer of coarse aggregate, shape it, roll lightly and then fill the voids with a finer aggregate. Water may or may not be sprinkled on the surface to assist in the void filling and binding process. Compaction is secured by frequent and protracted rolling.

These surfaces are seldom as smooth as those which use blading or dragging as a part of the construction process.

TYPES USING NON-BITUMINOUS, COLD ADMIXTURES

The non-bituminous methods may be classed as:

1. The surface application method.
2. The mixed-in-place method.
3. The pre-mixed method.

The Surface Application Method.—Calcium chloride is applied to the surface in flake or powder from a lime spreader. The spreader is hauled by a truck. Frequent light applications of ½ lb. per square yard appear to be favored over less frequent and heavier applications.

If a light surface mulch of fine gravel is retained on the roadway surface, the chloride appears to be more effective.

The Mixed-in-Place Method.—The principal work of this method has been experimental. Lime and portland cement is mixed with road soils. The soil is first loosened by plowing and harrowing. The admixture is then applied, followed by mixing with plow, harrow or road blader. The final surface contour is obtained by blading. Traffic does the compacting.

Premixed Method Cold.—Although limited in actual work done, this method is included because of future possibilities of utilizing local materials.

Portland cement is the binder.

The binder and aggregate are mixed in a concrete mixer, dumped and spread in much the same manner as standard portland cement concrete paving. The aggregates are quite fine (all passing the ⅜ in. screen) which allows unusual freedom in methods of finishing. A patented cement known as Soilamies cement has never been perfected.

BITUMINOUS TREATMENTS AND SURFACE COURSES

New construction methods with bituminous binders have been developed during the past four years. These methods are principally the results of usage with some field experimentation.

As in nearly all classes of road construction there are three principal methods of construction:

1. The penetration method.
2. The mixed-in-place method.
3. The premixed method.

Bituminous treatments as dust layers, will not be covered in this summary.

The Penetration Method.—This method is in common usage for penetration macadam. Quite recently a binder course of penetrated stone between base and top has been developed. The penetration method is used in all types of surface treatment work, that is, surface treatments which include one or more applications of bitumen and one or more spreadings of cover material.

For the dual treatment or two application method, the principal operations are:

1. Cleaning the base.
2. Application of prime coat.
3. Omission or spreading of light cover. (Omission is better.)
4. Second application of bitumen.
5. Immediate cover.

Note: The order of 4 and 5 may be reversed.

6. Spreading of cover with brooms or drags.
7. Compaction with a roller or by traffic.

Tightly bound surfaces of stone, gravel, sand clay, lime rock and various other surfaces are suitable for this method. The smoothness of the resulting surface is almost directly dependent on the smoothness of the surface to be treated.

The Mixed-in-Place Method.—From present indications the main features of the mixed-in-place method are growing in popularity. It is comparatively new. It was developed in Wisconsin about 1923 as a means for forming a bituminous surface on gravel roads which had a loosely bound surface. Today its principal features are used on sand clay roads, crushed and screened gravel roads and on old or new macadams.

A surface of appreciable thickness from ¾ to 3 in. compacted thickness may be constructed. The resulting surface is regular in contour and has smooth riding qualities. Minor irregularities in the old surface are automatically corrected by this constructive process.

There are two principal types of the mixed-in-place method; one in which no new aggregates are added to the existing surface, the other in which the base is undisturbed and new aggregates are added for mixing with the bitumen.

Using Aggregates Already in Roadway Surface.—1. Bring surface to be treated to a regular and smooth contour.

2. Scarify if necessary to the proposed depth of new surfacing, harrow, blade and shape.
3. Apply first coat of bitumen and mix with harrow and road blade.
4. Apply second coat and mix thoughly.
5. Sometimes a third coat is applied followed by more mixing. Mixing is continued until a uniform color results.
6. Follow with a final shaping by road blade or drag.
7. Secure initial compaction by rolling. Traffic may serve the purpose.
8. A seal coat of bitumen and chips, gravel or sand may be necessary.

Practice in some states calls for a blading of material to the road side. The exposed surface is then treated with a prime coat. This is followed by a second application. The material at the roadside is then bladed over the treated surface and mixed by blading back and forth across the road.

Using New Aggregates.—1. The old compact surface is smoothed and patched.

2. A prime coat of bitumen is applied and allowed to penetrate. It may be left under traffic for several days. A light cover of aggregate may be applied to prevent picking up by traffic.
3. If cover is applied it is bladed or turned over with a road machine set nearly cross-wise of the road.
4. The second coat of bitumen is applied and covered with aggregate.
5. Blading is continued until the cold mix begins to set up.
6. Compaction is preferably secured by a roller instead of traffic alone.

Final cover material may be applied before the second application of bitumen. There is no conclusive data to show which is the preferable sequence.

A third method may be used in which bitumen is mixed with the materials in the road and compacted in place; fol-

lowed by the addition of new aggregates which are treated and mixed with bitumen—making in effect two courses.

Premixed Method.—Premixed methods using hot mixtures are so well known that details will not be covered today. The hot mixed macadam as used in Canada differs but little from black base, two course construction.

The cold mixes are somewhat new, they offer few construction difficulties and interruptions to traffic.

When used on other than concrete bases a prime coat is growing in favor; as is also a thin bituminous binder course of stone penetrated or mixed with bitumen.

MAINTENANCE METHODS

There are three principal methods of keeping a road surface sericeable.

1. Addition of new materials which are similar to those in the existing surface.
2. Blading and dragging.
3. Patching.

All three methods including scarifying may be necessary on any one type of road.

The addition of new materials is common practice, and a necessity on gravel and sand clay roads. This is done at varying intervals of from one to four years.

Light blading or dragging from two to six times a week, regardless of weather, is the practise in states which have good gravel surfaces.

The heavy road machine and heavy road drag or planer are now being used on water bound, and bituminous macadams, and cold premixed types. Good results in securing a smoother surface are reported. The bituminous macadams are treated with a prime of bitumen the day previous to the planing.

Rollers for practically all types of bituminous surface treatments and surface courses are generally recommended for initial compaction.

The power distributor has practically replaced hand pouring methods for applying bitumens.

Large mileages of low type surfaces appear to be dependent on mobile equipment for economical construction and maintenance.

For experimental purposes and competition in bidding for work there appear to be some advantages in having several types of roadway surfaces, but a high quality of maintenance appears to be more easily sustained when the number of types is small.

COSTS OF CONSTRUCTION AND

Considering the costs and types of construction in the state highway systems only, the following table is made, for an assumed width of 18 ft.

Types Costing Less than $10,000 per Mile

Type	Miles
Sand Clay and Top Soil	11,395
Gravel, Chert, Shale, etc. (Treated and Untreated)	79,286
Total	90,681

Types Costing More Than $10,000 per Mile (including base)

Type	Miles
Water Bound Macadam (Treated and Untreated)	18,428
Bit. Mac. by Penetration	12,927
Sheet Asphalt and Bit. Concrete	5,706
Portland Cement Concrete	31,936
Block Pavements	3,380
Total	72,377

Surfaces costing more than $10,000 per mile are about 45 per cent of the total, and less than $10,000 are 55 per cent.

If we classify on a $20,000 basis then water bound macadam with and without surface treatments come below this figure. We then have 33 per cent costing more than $20,000 per mile, and 67 per cent costing less.

SELECTION OF TYPE

Selection of type is greatly affected by the availability of local materials. Thus we find sand-clays in several of the southern states, gravel in nearly every state in the union, stone in those states which can produce it economically and lime rock in Florida.

Our state highway systems have the largest percentage of high type surfaces, but this amounts to only 33 per cent of their total. Counties and townships have even a smaller percentage.

In their state highway systems Georgia, North Carolina, South Carolina, Vermont and Virginia, each have over 1,000 miles of sand clay; Arkansas, Colorado, Louisiana, Michigan, Minnesota, Mississippi, Ohio, Texas and Wisconsin each have over 3,000 miles of treated and untreated gravel; Indiana, Kentucky, Maryland, New York, Ohio, Pennsylvania, Tennessee, and Virginia each have over 1,000 miles of treated and untreated water bound macadam.

A study of Federal-aid road mileage shows sand clay as 9.3 per cent, gravel 38 per cent, water bound macadams 2 per cent.

For Federal-aid roads the statement is made by the Bureau that sand clay is decreasing in popularity, gravel shows little change and water bound macadam a decrease.

The higher type surfaces show an increase in popularity on Federal Aid, work with portland cement concrete showing the greatest gain.

In 1924 the total surfaced mileage in the country was 467,905.

	Per cent
Sand Clay	13.6
Gravel	52.2
Surface Treated Macadam and Gravel	5.7
Water Bound Macadam	12 9
All other types	15.6
Total	100.00

Among the several untreated types of surfacing the traffic bound stone, slag or gravel surface as built in Ohio is an excellent example of good low cost road service.

Calcium Chloride in Michigan has served as a satisfactory dust layer on gravels.

The dual surface treatment work on lime rock in Florida is excellent.

The mixed-in-place methods for resurfacing old macadams as practised in Pennsylvania and Tennessee are smooth and serviceable.

The mixed-in-place methods on gravel or stone surfaces as practised in Wisconsin, California, Indiana and Minnesota give promise of a satisfactory method of greatly improving many miles with this type.

The dual surface treatments as practised in Maine, on gravels and North and South Carolina on sand clays show reasonable results.

The experimental work in South Carolina for improving the serviceability of poor quality sand clays is a step in the right direction.

Selection of type is a prescription proposition.

An engineer who is already familiar with the local conditions of his own surfaces, available materials and funds, will do well to make an examination of the work done by others under similar conditions. His final choice will be more easily and intelligently made.

SELECTION OF CROSS SECTION

From a study of typical cross sections there appear three principal types for untreated surfaces; the feather edge, from out to out shoulder; the trench section of uniform thickness; and a combination of the trench section for the middle two thirds which is topped with a feather edge section extended to the outer edges of the shoulders.

Surface treatments and surface courses are usually of uniform thickness. They extend in most instances over the entire width of old surface.

Edge strengthening is being considered as evidenced by sections which show a wider base than top, a thickened edge similar to the Bates section, the use of headers of bituminous concrete, portland cement concrete or timber.

A section stepping up by using a decreasing width of surface for the various courses is shown by one state.

There is a marked tendency toward flatter crowns. Few exceed ½ in. to the foot, many show in plan and in the field ⅜ in. to the foot and some recommend and use as low as ¼ in. The growing popularity of the flat crown is apparent in untreated surfaces, surface treatments and higher type pavements.

SERVICE

Road service is frequently reckoned on the cost of maintenance per vehicle-mile or per ton-mile. There is no good reason for not including the cost of construction.

A few states are trying to make their selection of type on the cost of maintenance basis. Reports indicate that they have not made definite conclusions as a result of their observations.

Based on statements and claims made by highway engineers in responsible authority the following data are presented:

Sand clay surfaces cost from $1,000

to $2,400 per mile, they will carry from 150 to 550 vehicles per day, including light trucks, at an annual maintenance cost of $300 to $600 per mile.

Gravel surfaces cost from $4,000 to $10,000 per mile and will carry from 250 to 550 vehicles per day including light trucks, at an annual maintenance cost of $300 to $600 per mile.

Untreated water bound macadam surfaces cost more than gravel.

Traffic bound stone, slag and gravel surfaces cost about $2,000 per mile the first year, $1,000 the second, and $500 the third, they will carry 300 to 600 vehicles per day including light trucks.

Dual bituminous treatments on good substantial bases cost $1,000 to $3,500 per mile for the firt year, and will carry from 700 to 1,000 vehicles per day, including light trucks, at an annual maintenance cost of $400 to $1,000 per mile.

Mixed-in-place bituminous surfaces depending on their thickness are costing from $1,000 to $4,500 per mile, and are reported to be carrying about the same traffic as dual treatments at about the same maintenance cost.

They are smoother riding than dual treatments, and they should be more durable.

Premixed surfaces and penetration macadam cost from $8,000 to $15,000 per mile and will carry from 1,500 to 2,500 vehicles per day at an annual maintenance cost of from $200 to $500 per mile.

In some instances they are carrying heavier and denser traffic.

Tire wear has been shown to be heavier on untreated surfaces.

Traffic bound mixed-in-place surfaces are smoother riding than surfaces which are rolled only.

Character and quality of service are affected by climatic, soil and organization conditions.

Gravel roads require more frequent scarifying in states which have severe frost conditions.

Dust is a much more serious problem in Arizona than in Alaska.

Several states reduce the number of vehicles and their weights during the period when frost is leaving the ground. A reduced maintenance cost results.

New Portable Heating and Thawing Outfits

The contractor who is doing winter work will be interested in the new portable heating and thawing outfits recently announced by Connery & Co., Inc., Second and Luzerne Streets, Philadelphia. One outfit was designed to thaw out frozen car hoppers, frozen switch systems, material piles, car valves and pipes, for melting ice and snow on any work, for drying out concrete prior to waterproofing, for drying and heating sand and gravel, and for preheating in connection with welding. The other outfit has been specially designed for heating woodburning asphalt kettles. A feature of the preheater is that it needs no source for compressed air, but is equipped with a hand air pump. It burns equally well kerosene, coal oil, or light furnace oil. Various models of each, depending upon size of tank, length of hose, and so on, are available. The same concern manufactures oil burning tar and asphalt heaters.

Two New Attachments for P & H Groundhog

The ½ yard excavator brought out by Harnischfeger Corporation early in 1927 met with a widespread demand. Large general contractors such as Booth & Flinn, Inc., of Pittsburgh, Pennsylvania, as well as small excavating contractors throughout the country are said to have found numerous uses for the P & H Groundhog.

When the new machine was first placed on the market Harnischfeger Corporation anticipated that shovel, dragline, clamshell, and pile driver attachments would meet all requirements, in the ½ yard size. However, trench hoes and skimmer scoops were soon being called for, and in response to this demand the manufacturer designed two additional attachments.

The hoe and skimmer booms are built up of heavy I-beams securely trussed and braced. All joints are electrically welded to provide the maximum rigidity and strength.

The hoe can dig to a depth of 16 feet. By shifting the course of the boom and bucket any width of trench can be cut. The hoe dipper is shaped from heavy boiler plate and the seams are electrically welded.

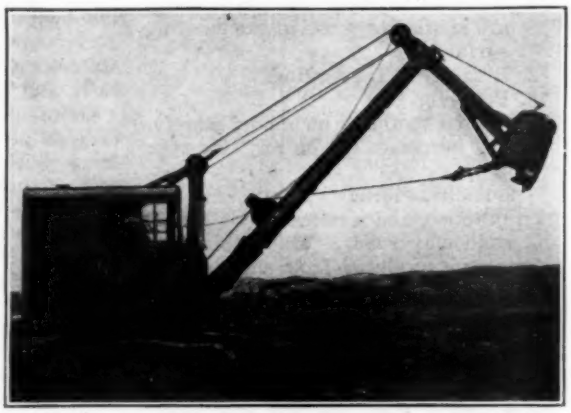
The skimmer bucket is constructed of heavy boiler plate and has a horizontal travel of 13 ft. Heavy spring bumpers are cast integral with the boom foot, thereby eliminating heavy jolts on the boom as bucket rolls back to the machine.

All five P & H models are convertible for use as shovel, dragline, trench hoe, skimmer scoop, clamshell, pile driver, etc., by a simple change of booms or attachments. It is never necessary to change the drum, as a special patented spider is permanently installed on the power drum. The laggings required for various classes of work are split in two sections and can be quickly bolted to the drum spider. All wear consequently develops on the inexpensive laggings and not on the drum.

Traffic Delays Found to be Big Factor in Cost of Living

The important part played by traffic congestion in determining the costs of virtually every commodity that effects the cost of living has been strikingly brought out in traffic surveys conducted in several of the larger cities by the Albert Russel Erskine Bureau for Street Traffic Research.

The latest survey completed by the Bureau, which is endowed in Harvard University by The Studebaker Corporation, covered every aspect of the traffic problem in San Francisco. It developed the fact that in the case of many commodities the cost of transportation from freight car to customer ran from 33 per cent to 81 per cent of total transportation costs.



P. & H. ½ Cu. Yd. Trench Hoe

In Chicago the survey found that the haulage cost on coal amounted to approximately 90 cents a ton, which represents close to 50 per cent of the freight cost.

"The principal agencies which carry persons and commodities over the streets operate at ascertainable costs," says Miller McClintock, director of the Erskine Bureau, in commenting on the findings. "Obviously the delay these agencies suffer because of traffic congestion adds to their cost of operation and results eventually in higher prices to the consumer."

"When the proportion of these costs to the total operating cost is discovered it becomes obvious that reduction in delays through improved traffic control will exert a material influence in reducing the cost of many commodities and services to the ultimate consumer.

"As examples, the San Francisco survey was informed by the management of the largest taxicab company operating in the city that if it were possible to improve street conditions even 10 per cent the company would save in equipment costs alone not less than $20,000 a year.

Asphalt Paving Mixtures

Paper Presented Dec. 1 at the Sixth Annual Asphalt Paving Conference

By FRANCIS P. SMITH
Chemical Engineer, New York, N. Y.

THE stability discussed in this paper is that property of the paving mixture which tends to resist displacement under traffic wear and impact.

Asphalt paving mixtures ordinarily consist of:

Asphalt cement.
Filler.
Mineral aggregate.

In some types such as black base, binder, etc., the filler is omitted. Variations in the stability of such mixtures (unless we are to consider an increase in the number of constituents) can therefore only be produced by varying the physical characteristics of the three constituents or the relative proportions of each entering into the mixture. Apart from the constituents of the mixture, the stability of the finished pavement is also greatly affected by the kind and character of the foundation, the uniformity of the mixture, the perfection of workmanship and the amount of compression which it receives during laying. These factors, while of major importance, will be discussed chiefly in connection with variations in design affecting the workability of the mixture.

Asphalt Cement.—The function of the asphalt cement in a paving mixture is chiefly to bind the particles together. It also serves to fill the voids and make the mixture waterproof or nearly so. An ideal asphalt cement for this purpose would be one that was but slightly affected by temperature changes within the ordinary atmospheric limits of say 10 deg. F. to 150 deg. F. and which maintained a fairly constant and adequate plasticity and adhesiveness throughout that range. It should also liquify readily at 250 deg. to 300 deg. F. With such an asphalt cement the problem of attaining satisfactory stability in asphalt paving mixtures would become a simple one. Unfortunately all asphalt cements are markedly affected by temperature changes within the lower range mentioned and rapidly pass from the solid and at times brittle state at 10 deg. F. to the semifluid state at 150 deg. F. or above. A paving mixture made with an asphalt cement of such consistency at 77 deg. F. that at the temperature it would have the proper plasticity and stability, should be undesirably hard at 10 deg. F. and would be lacking in stability at 150 deg. F. Temperature therefore is a very important stability factor and its effect is almost wholly confined to the asphalt cement, the mineral aggregate and filler, constituting approximately 90 per cent of the mixture, being practically unaffected.

Different asphalt cements vary somewhat in their susceptibility to temperature changes and many efforts have been made to reduce their susceptibility by combining different bitumens, by blowing and by the addition of chemicals. Neither of the last two methods has proved successful in the long run and in many cases it is imperative to use the asphalt produced locally.

Until and unless the susceptibility of present day asphalt cements to temperature changes is reduced, hardening the asphalt cement used or reducing the amount of it are the only ways in which, with a given aggregate, the stability of a paving mixture can be increased.

Both of these methods however have serious drawbacks and limitations. Hardening the asphalt cement makes a mixture which must be handled at a higher temperature and which is more difficult to rake and is much more difficult to compress. If carried too far, it makes a mixture which is so brittle in cold weather that it will not resist abrasion and may grind out and rut badly under tire chains in a single winter. High mixing temperatures are liable to injure the asphalt and still further harden it and are very difficult to maintain in cold weather, when so many pavements are laid. Difficulty in raking makes for uneven contour and imperfect compression which frequently more than offsets increased stability.

Compression and Stability.—Lack of compression is probably the greatest factor of all in decreasing stability. In most cases a pavement made with a relatively soft asphalt cement will have a satisfactory density owing to the comparative ease with which it can be compressed and for this reason may in practice have a greater stability than if a hard asphalt cement were used. With a hard asphalt cement, special care and heavier rollers are required in cold weather to secure adequate compression and this applies to lean mixtures also. If this compression is not secured, all the advantages of using the hard asphalt may be lost and a much inferior pavement result. Eight to ten-ton tandem rollers (a quite usual contractor's equipment) are sufficiently heavy to properly compress a relatively soft mixture in late fall but are entirely inadequate for compressing the harder mixture under similar conditions. The direct relationship between compression and stability is very clearly shown in the results obtained by Hubbard & Field when working with a normal mixture compressed at 1,000, 2,000 and 3,000 lb. per square inch.

Compression	Stability Load
1,000 lb.	800 lb.
2,000 "	1,100 "
3,000 "	1,475 "

Lack of Stability in Summer.—Lack of stability in a pavement is chiefly apparent in summer time. At this season, a mixture rich in bitumen will be much less stable than a leaner mixture, although at lower temperatures this difference is much less marked. Assuming adequate compression there is less intimate contact in a rich mixture between the particles of the mineral aggregate than in a lean one and the fluidity of the cementing medium has a marked effect. Reduction in the amount of bitumen brings the mineral particles more closely in contact and permits them to exert a greater retarding influence to displacement. Great care must be exercised however that this reduction is not carried too far and that the mineral aggregate is of the proper character. In a relatively coarse mixture the particles should be thickly coated with bitumen thus increasing the rather limited area of contact. It would be impractical to attempt to fill the voids of such a mixture with asphalt as it would not retain it. As the mixture increases in fineness the voids become smaller, the contact area increases and up to a certain point the bitumen should be increased to provide for the increased surface area. In both cases the particles are covered with a fairly thick film of asphalt, part of which, under compression, finds its way into the comparatively large voids. With a still finer mixture the area of contact is further increased and the size of the voids reduced. Under compression, there is less available room for the excess asphalt and unless it is reduced in quantity, the mixture will be too rich. In every case, however, each particle must be coated with asphalt. The surface area to be coated and also the contact area are greater in the fine mixture than in the coarse one and under these circumstances a thinner coating of bitumen gives greater stability. In the opinion of the writer neither surface area or voids taken independently are a proper basis for mixture design. The should rather be considered together in their proper relationship.

Fine aggregate, low bitumen mixtures present much the same handling difficulties as do mixtures made with hard asphalt cements. Ultimate compression of such mixtures is extremely difficult and requires heavier rollers.

Shear Strength.—Working with an aggregate composed of 70 per cent of sand and 30 per cent of limestone filler, to which 6 per cent of asphalt cement was added, Abson obtained a shear strength of 53 lb. and 10.7 per cent of voids after compression at 5,000 lb. per square inch (the equivalent in practice of a 10-ton 3-wheeled roller) against 72 lb. shear strength and 5.2 per cent voids after compression at 18,000 lb. per square inch—the latter pressure being unobtainable in present paving practice. Using the same aggregate but with the asphalt cement increased to 10 per cent, the shear strength while much lower than in the lean mixture was the same after 5,000 and 18,000 lb. compression respectively and practically no difference was found in the voids. These results are cited to show the necessity for what may be termed special handling of the extreme type of high stability mixtures in order to justify the design and secure satisfactory results. If these precautions are not observed the pavement will be inferior to one made with a mixture having a lower stability factor but which handles and compresses more easily. This is in no sense a plea for inferior workmanship but working and climatic conditions are at times just as important considerations as mixture design per se.

The thickness of the bitumen film on the particles of the mineral aggregate is important from the standpoint of its weather resisting qualities and also to provide for the plastic flow of the mixture under traffic. With the grains in intimate contact and the bitumen film extremely thin, the movement of the grains on each other may rupture this film. Unless the film is of sufficient thickness re-cementation will not take place.

The rock asphalt pavements of Europe are extreme examples of fine aggregate low bitumen mixtures. It is impossible to compact them by rolling alone. Hot tampers must be used over the entire surface and the pavement when first laid usually has only a skin of ⅛ in. thickness throughout which the compression is thorough. The lower layers of the pavement are only partially compressed and serve as a cushion to traffic impact. There is little or no plastic flow in these pavements and hence a minimum of rupture of the cementing films of asphalt.

In connection with the United States type of asphalt mixtures, an interesting field for further research would be in the stability of mixtures before and after continuous plastic flow for a considerable period of time. Certain pavements appear to maintain reasonable smoothness of contour for a period of years and then quite suddenly develop extreme waviness. In some instances this is due to the weakening of the bond between the particles through water action on the bitumen. In other cases no water action is apparent and the cause is obscure. Long continued fatigue stress of the bitumen may eventually result in lowering its cementing value. Ultimate compaction may also exert a deleterious action in some cases as perhaps illustrated by the jellying effect of overtamping with hot tampers.

Filler.—Up to the present we have chiefly been considering the effect of variations in the asphalt cement while the filler and mineral aggregate remained constant in character and amount. In the case of the filler, we may vary its composition, fineness and amount. Its function is to reduce the voids in the mineral aggregate both as to size and amount, thus increasing the contact area and inherent stability of the aggregate itself. Its stabilizing effect on the dry mineral aggregate can be readily demonstrated by mixing the dry filler and mineral aggregate and introducing the mixture into an ordinary measuring cylinder. After a little tapping the cylinder may be held in an inverted position without any of the dry mixture running out. This would be impossible before the addition of the filler. The voids in the mineral aggregate vary considerably in size. It is undesirable to fill large sized voids wholly with fine material as this has a tendency to produce a bally mixture. A certain percentage of relatively coarse particles should therefore be present in the filler, the amount theoreticaly being dependent upon the mesh composition of the mineral aggregate. The most commonly used filler is limestone dust. Next in importance is portland cement. Ground silica, slate dust, soapstone dust, clay and hydrated lime have also been used. With the possible exception of the last named, none of these fillers have any chemical action on the asphalt cement. Methods for determining their fineness with any degree of exactitude have not been in common use. Most specifications call for a minimum percentage passing the 200 mesh sieve. Based on this method of classification, there have been many unexplainable differences in the action of fillers of the same type and degree of fineness. Two samples of limestone dust from different manufacturers having the same amount passing the 200 mesh would produce mixtures varying from very sloppy to stiff when used in mixtures in which the only variant was the make of filler. Many service tests have indicated that portland cement would usually produce a stiffer raking mixture than would limestone dust, although stability tests on the compressed mixture have failed to show any difference. Immersion tests on mixtures identical except that one contained silica dust as a filler and the other limestone dust, have shown a much greater resistance to water action on the part of the limestone mixture. The particles of certain fillers are strongly absorbent towards asphalt and many clays are strongly absorbent as well. On the other hand certain clay asphalt mixtures when immersed in water swell badly and quickly disintegrate while those made from other clays do not. Apart from the physical functions of reducing voids there is much in connection with fillers and their action on paving mixtures that we do not yet understand. As stabilizing factors their value is largely dependent upon fine grinding although this may be carried to excess, a certain proportion of coarser particles being requisite for the production of the best results especially when used with relatively coarse sands. Up to a certain point the stability of a given mixture increases directly with the amount of filler added. Beyond that point the mixture may become excessively rich and a reduction in the amount of asphalt used may be required in order to produce the maximum possible stability. Increases in stability produced by increasing the amount of filler must be regulated in accord with the workability of the mixture. The introduction of too large an amount of cold dust in a mixture calls for heating the sand to an undesirably high point and is another regulatory consideration.

Mineral Aggregate.—Owing to time and space limitations, only a sand mineral aggregate will be discussed. Such an aggregate presents practically the same problems as are met with in larger sized aggregates.

Sands vary in their grading, the size and shape of the particles and to a smaller extent perhaps in the chemical composition of the particles. The two most important factors influencing the stability of the sand per se are mesh composition and shape of grains. The mesh composition which will produce the maximum stability for a given sand has never been accurately determined. It would involve a great deal of experimental work and the figures so obtained would probably not hold for other sands. It is generally recognized however that a certain proportion of 10, 20 and 30-mesh grains are desirable as they lower the voids and being less mobile than the smaller grains add to the stability. A certain proportion of 80 and 100-mesh grains are also desirable as they reduce the size of the voids to be filled by the filler. For reasons already explained it is undesirable to have these voids too large. With these two requisites fulfilled the relative amount of 40 and 50-mesh grains is not very important. These grains act as primary fillers for the largest size voids. Grains which have been rounded and worn smooth by water action tend to make an unstable mixture as they move readily upon each other and asphalt does not adhere

to them as well as to grains with rough, pitted surfaces. Certain sands appear to absorb asphalt to a certain extent while others, notably those composed largely of flint grains will retain only a very thin coating of asphalt. This perhaps is more important in connection with the water resistant qualities of the mixture than from the standpoint of stability. From the standpoint of our present knowledge, mesh composition, shape and character of grain surface are factors which can be utilized to increase stability. Where only a single sand supply is available, the only possible variants are the other two ingredients of the mixture. Sands exhibit marked differences when made into mixtures which opens up interesting fields for investigation. Two sands having the same mesh composition and voids may vary greatly in their capacity to hold asphalt either by themselves or after the addition of filler. This has never been satisfactorily explained.

It is also interesting to speculate whether sand grains which will only carry a very thin coating of asphalt are perhaps desirable from the standpoint of stability due to the high surface tension of the thin film of cementing medium as compared with the lower surface tension of a thicker film.

Within the limits of a single paper it is impossible to discuss at length all the factors affecting stability. Those most interesting at the present time are chiefly connected with the design and proportioning of mixtures. Equally important are the questions of durability, manufacture and laying and these must not be subordinated to extreme stability.

Aeroplane in Highway Location

The aeroplane has now come into use as a factor in highway location. Read the following from November California Highways:

"On Oct. 24 F. W. Haselwood, District Engineer for District III, left Sacramento in a Forest Service aeroplane to view the North Fork and the Middle Fork canyons of the Feather River from the sky. The plane was piloted by Captain Boggs. In three hours after leaving Sacramento, Mr. Haselwood was back in Sacramento. The plane flew at an approximate height of 5,000 ft. and at a speed of 90 miles an hour.

"From Sacramento Mr. Haselwood and Captain Boggs flew direct to Oroville and from there to Bidwell Bar. The Middle Fork Canyon was then followed to Cromberg, where the plane turned, returning via Quincy, Spanish Creek and the North Fork to Oroville and Sacramento.

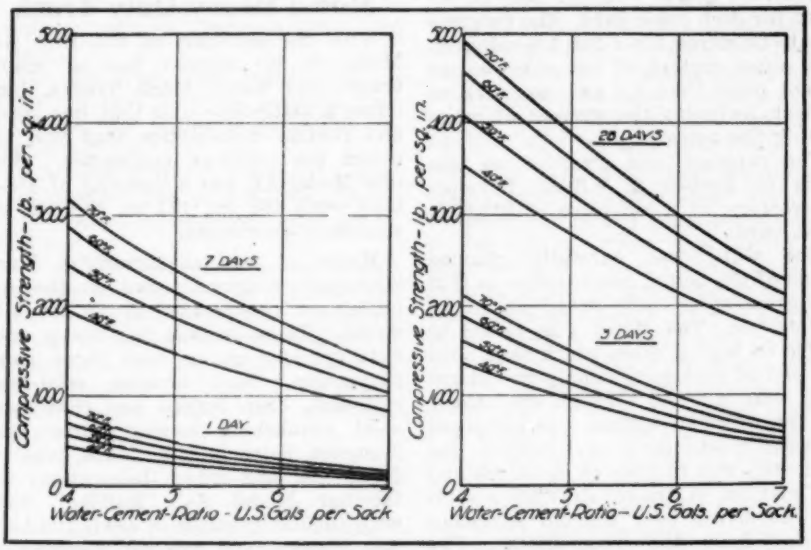
"Mr. Haselwood states that a surprisingly accurate view of the country can be obtained in this manner, and that no difficulty was experienced in recognizing landmarks. A very excellent idea of the topography of the country was obtained."

High Early Strength Concrete from Portland Cement

From December Concrete Highways.

The interest in concrete of high strength at early ages, particularly in connection with highway work, led to an investigation of methods for securing this property with standard portland cement. A number of factors contribute to increased strength at early ages, the more important being the quantities of cement and mixing water and the temperature of curing.

Relation Between Compressive Strength and Quantity of Mixing Water. — The accompanying figure shows the relation between the compressive strength of concrete when cured damp and the quantity of mixing water at 4 ages for different temperatures of curing. The data for 70° F. are based on laboratory tests using average materials and following standard methods of test of the American Society for Testing Materials. The data for the other temperatures were deduced from these by means of the relative compressive strengths at different temperatures reported in Bulletin 81, University of Illinois Engineering Experiment Station, "Influence of Temperature on the Strength of Concrete," by A. B. MacDaniel.



Relation Between Compressive Strength and Water-Cement Ratio.

It may be seen from the diagram that if 2,000 lb. concrete is required at 3 days, it can be secured by using a water-cement ratio of 4¼ gal. per sack and curing at 70° F.; the corresponding strengths at the other ages are about 700 lb. at 1 day, 3,000 lb. at 7 days, and 4,600 lb. at 28 days.

Offsetting Effect of Low Curing Temperature.—The diagram also shows rather clearly how the effect of low curing temperature may be offset by use of less mixing water. For example, if 1,000 lb. concrete is desired at 3 days, it may be secured by using 6 gal. of water per sack of cement and curing at 70° F., or at lower curing temperatures, by using the following quantities of water: 5¾ gal. and curing at 60° F.; 5¼ gal. at 50° F.; and 4⅞ gal. at 40° F. It must be borne in mind that when using these lower quantities of mixing water per sack of cement, more cement will be required to produce concrete of a given consistency or condition of workability.

From the foregoing, it is evident that in cold weather the cement requirement for concrete may be maintained at a minimum by heating the materials and by curing at the higher temperatures. When high early strengths are required, a combination of low water-cement ratio and normal curing temperature will produce the best results.

For concrete cured at normal temperature, increasing the mixing time from 1 to 2 minutes will add about 100 lb. per square inch to the strength at 3 days, and increasing the mixing time from 1 to 5 minutes will add about 200 lb. per square inch. The additions to the 1-day strength will be about half of these amounts.

Calcium chloride of calcium oxychloride may be used in portland cement mixtures to increase the early strengths. Different cements behave differently with these admixtures and trial batches with the admixture to be used are recommended before using in important work. With some cements, 2 to 4 per cent of calcium chloride, or 7 to 10 per cent of calcium oxychloride by weight of the cement gives the greatest acceleration of strength and will not result in decreased strengths. These compounds should not be used, however, as a substitute for heating the materials and proper curing.

Concrete Pavement Opened to Traffic in 13 Days

By using high early strength concrete in paving 4th avenue, at Olympia, Wash., it was possible to throw open the pavement to traffic in 13 days. We are indebted to an article by Charles I. Signer, city engineer, in the January issue of Concrete Highways and Public Improvements, for the following particulars:

The old concrete base was found by testing to be in perfect condition and by removing the old wood block surface and the 1-in. sand cushion a new concrete surface approximately 5 in. thick could be laid. With this thicknes it was possible to maintain the original grades at intersections and at the curb and street railway tracks.

Specifications called for a concrete mix of 1:1½:2½ with 2.1 bbl. of cement for each cubic yard. The concrete was to be mixed for a full 1½ minutes. The water content of the mix was set at not more than 4.4 gal. per sack of cement, including the amount of moisture in the aggregates.

The contract was awarded on this basis to Forbes & Wilder, Olympia contractors, at a bid price of $12.66 a cubic yard.

The work was carefully planned ahead of the actual construction so that the greatest possible speed might be maintained. The street was closed to traffic on May 2, from which time until the end of construction only two street cars were allowed through operations. As the original surface was composed of wood blocks on a sand cushion, the first step was to remove the block and the cushion. A tractor drawing a rooter was driven over the old pavement tearing loose the wood blocks. The blocks were then loaded by hand into trucks and carried from the street. The blocks were sold for fuel. Placing of concrete began on May 5 and was completed by May 9. The entire street was opened to full traffic on May 14, only 12 days after the street was closed. Heavy trucks with solid tires were kept off the pavement until May 24.

The concrete resurfacing extends from Jefferson Street to Capital Way. The area resurfaced is 5,040 sq. yd. The new pavement is 40 ft. wide between curb lines with a single street railway track down the center. The street railway track area was resurfaced with the same concrete mix at the time the street was laid.

The new pavement is divided into panels approximately 15 ft. square. The minimum thickness laid was 4 in. and the maximum 6 in. with an average thickness for the job of 4¾ in. A ⅜-in. strip of Elastite filler was placed between the new pavement and the old curbs.

Every precaution was taken to get quality and high strength concrete. As the work progressed cylinders were cast on the job and tested at varying ages. In designing the high strength mix it was assumed that the mix determined upon would give a strength of 3,600 lb. per square inch at an age of 7 days. The cylinders showed, however, that this strength was attained at the end of 5 days and that at an age of 8 days strengths of 4,000 lb. per square inch were being secured. The cylinders tested were cast each day and were cured alongside the pavement under the same conditions prevailing on the street pavement slabs.

The factors of high early strength followed were: Increase in cement content, decrease in the amount of mixing water, extension in the time of mixing and continuous water curing at temperatures of from 60 to 70 degrees.

Mack Announces New AK Model Heavy Duty Truck

With the addition of the new AK Model to its regular line of motor trucks and buses, Mack Trucks, Inc., offers a distinctive unit that has speed and control possibilities that will interest the highway contractor. The new Model AK has a capacity of 3½-5 tons, with 162 in., 174 in. and 186 in. standard wheelbases.

Many of the characteristic Mack "Bulldog" features found on the AC model are incorporated in the new AK model. These include the heavy duty four cylinder engine with three point suspension, heat treated semi-steel cylinders, drop forged and case-hardened crankshaft having three inch diameter journals; the Mack type of force feed and splash lubrication; the familiar Model AC "Bulldog" hood with tubular radiator in cowl, and beltless blower type fan all mounted in rear of engine; the Mack water pump of the balanced bronze rotor type; the clutch of large single disc type; and transmission with four speeds forward and one reverse with gears mounted on patented Mack interrupted spline shaft.

In addition to the special Dual-Reduction drive, the efficient standard Model AC chain drive is also offered on the new Model AK.

Many special features are found on Model AK. The engine of 4⅝ in. bore and 6 in. stroke has cylinders cast en bloc with detachable aluminum heads. The transmission is suspended in four blocks of live, resilient rubber held under compression. An additional feature of the transmission is an extra high speed reverse which may be obtained at a slight extra cost. A cover opening at the side permits easy accessibility to the transmission without removing the floorboards.

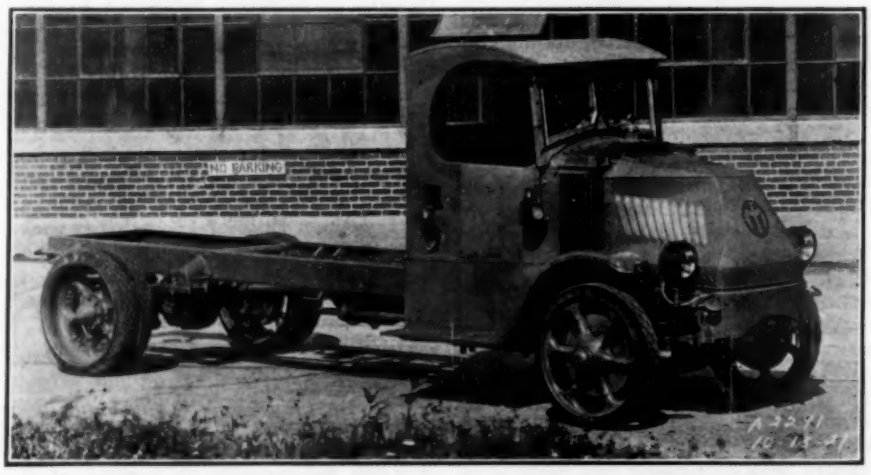
Springs are rubber shock insulated, reducing vibration to a minimum and also eliminating entirely the lubrication problem of metal shackles.

Being a high speed heavy duty carrier, four wheel brakes of the internal expanding type have been made standard on this model. The emergency brake operates mechanically and is of the external contracting type. On the chain drive model it is located on both jackshafts while on the dual reduction model it is mounted on the rear end of the transmission.

Model AK has a sharper turning circle than ever before offered on Mack trucks. This has been effected by center point steering which makes for exceptionally easy handling in traffic.

A forty gallon gasoline tank is mounted under the driver's seat with the filler opening through the right side of the cab. The cab itself is all steel with sliding doors and is mounted in rubber shock insulators. In addition to shock insulating the cab, the seats themselves are mounted in rubber, again emphasizing Mack's extensive use of rubber at points of vibration.

British Columbia May Expend $4,000,000 for Roads.—A $3,000,000 to $4,000,000 road improvement loan is contemplated by the Provincial Government of British Columbia, Victoria, B. C. The money will be necessary to carry out the road program for this year.



View of One of the New Mack Trucks

Highway Finance

Its Uses Outlined in Address Presented Dec. 2 Before Highway Research Board

By A. J. BROSSEAU
President, Mack Trucks, Inc.

The American Public has an investment of $10,000,000,000 in rural highways.

Annual expenditures for the last few years have been at the rate of $1,000,000,000 a year, and there are reasons for believing that annual expenditures will soon be at the rate of $1,250,000,000 and probably become stabilized at that figure.

Authorities agree that 60 percent of the amount expended is for construction and the balance is devoted to maintenance.

I speak of this at the beginning of my address because there is very general misunderstanding of the terms "Expenditure" and "Expense." Expenditures to pay for income producing facilities charged to capital account, are one thing. Expenditures for maintenance expense, are another thing.

We are, therefore, faced with a situation of having a $10,000,000,000 investment in highway facilities to which we will add $750,000,000 a year, and an annual expense of $500,000,000 for maintenance.

Is the capital structure of this transportation system sound? Who has paid and who will continue to pay, for these facilities? Are dividends paid? If so, who receives them?

Uses of Taxes Overlooked in Demand for Economy.—These questions are asked because of the demand for economy in our Federal, State and local governments. Because there is a tendency to look upon all taxes as expense, one should remember that in the case of highway expenditures a very large amount is not expense, but is an investment in income producing facilities.

No one, I take it, will disagree with the statement that every possible economy should be practised in the expenditure of public funds. Nor will any one say that taxes would be levied at random, but rather only after careful and thorough consideration of the uses to which the money is to be put.

The spending habit is one easily acquired, so we must make sure all expenditures are for those things which have justifiable earning powers.

Taxes Essential to Expansion of Facilities.—But, these facts admitted, and with constant vigilance in our public expenditures, it still remains true that Government, like business enterprises, must have funds for the expansion of its capital facilities if it is to fulfill its function of providing for the needs of its citizens.

While this discusion is directed chiefly toward highway finance, it is necessary to analyze the general activities of Government in order that we may have a proper conception of the relation which highway expenditures bear to the total.

First, let me point out that all Government expenditures can no more be classified as expenses than can the entire budget of any business. Both must provide funds for capital structures. Both must provide money for expenses incidental to the maintenance of the policies of the stockholders. In the case of the Government these stockholders are its taxpayers.

Expenses Versus Expenditures.—Government is a great community enterprise which must cover a wider range of activities than any private business.

If we examine the structure of our Federal Government we find that its functions can be grouped into two classes.

Into the first come legislative, executive, judical, national defense, payments on war debts, pensions and related activities.

In the second will be found all classes of property—such as national forests, public parks, reclamation and public buildings.

All of the items in these two divisions are comparable for Federal and State, but there is a great similarity between them, and the classification of expenditures of the Federal Government will apply to many of the operations of State, county and municipal governments.

I desire to emphasize that while expenditures in the first group are necessary expenses, expenditures in the second group cannot be properly charged as expenses. They must be considered as capital expenditures and the amounts must be justified by the returns which they give to the public. Mere amount is not the issue.

Uses of Highway Finances and Returns.—This brings us, then directly to the question of the uses to which highway finance are put and the returns which they give.

If we view the question as an administrative one it will be found that rural highway expenditures fall into two groups, State and local, since Federal funds are expended by the States.

Each of these groups divides its appropriations into two classes—construction and maintenance, with the former constituting about 60 per cent of the total amount.

Through the construction fund, year after year, roads are built which are kept in service through the maintenance account. Each mile so constructed and maintained, adds to the capital facilities of the nation or the community, and by doing so contributes in some way to the well being of every citizen.

Every Citizen a Stockholder.—As for the capital structure of our highway system, there are no Federal bonds, only common stock (one might say) held by more than 115,000,000 citizens.

The total State bonded indebtedness for highway purposes at the beginning of 1927 was about $835,000,000 with interest payments, approximating $34,000,000, and principal payments another $22,000,000.

Unfortunately, accurate figures as to county and local indebtedness are not yet available, but the fixed charges appear to constitute a very small portion of the total expenditures.

Since 1916 only twenty-five States have issued bonds for highway purposes. The fact is, of course, inconclusive as to the advisability or inadvisability of the use of bonds for highway building since each State must gauge its need independently.

In many cases, however, the proud boast of the State that it is "paying for its roads as it goes" is attained at the expense of counties overburdened with highway bonds issued to build main roads which were the logical obligations of the State as a whole.

In the past, long term bonds were quite generally issued, but lately the tendency has been toward serial bonds, to be retired within the life of the original construction. There does not seem to be any justification for the fear that roads will "wear out," or be "destroyed," before the bonds are paid for. To illustrate, New York State issued some $100,000,000 in bonds more than a decade ago to build a highway system. The unexpected increase in motor use soon rendered the narrow light-surfaces obsolete. New York did not scrap these roads, but used them as a base for wider, stronger roads, thus modernizing the system at a comparatively small additional cost. I am informed that the "present value" of these roads, at the time they were rebuilt, was more than the original cost.

Who Pays for the Roads Today?—Who pays for the roads? To illustrate, let us call the citizens of our country the stockholders who operate through their Boards of Directors, the members of Congress. They have long since recognized the need of a national system of highways and are cooperating with their subsidiaries—the States—in the construction of such a system, and with them are sharing the cost. The Federal contribution is something like 8 per cent of the total annual rural highway bill.

The motor user is paying in taxes very nearly 50 per cent of the total, exclusive of Federal Aid. Bonds and general taxes are resorted to for the balance, although the bonds are in many instances being retired from motor taxes.

So, our source of revenue is well spread and on a wide base. I doubt if anyone, today, can successfully challenge the statement that the motorist

is paying for highways in the ratio of the benefits he receives.

Is the Highway System Paying Dividends? Who Receives Them?—We learn from the U. S. Census Bureau that the cost of highways is fully reflected in enhanced real estate values, and so adds tremendously to taxable property. And from the Federal Trade Commission study of national wealth, we learn that the definite valuations placed upon our highway facilities show a handsome return on cost.

The beneficial results upon our primary education through school consolidation, made possible by the improved road and the bus, is another of the many dividends paid by roads.

Our unequal rail transportation system would not function without our present highway facilities.

Other Dividends Many and Large.—The national defense has profited by the spirit of national unity developed by the highway and motor vehicle.

Rural free delivery, rural libraries, rural hospitals, police, fire and sanitary protection, have all followed an enlightened program of highway building.

We all receive our share of these dividends—whether we own cars or not—and it is not too much to say that our modern standards of living would be impossible without our improved highways.

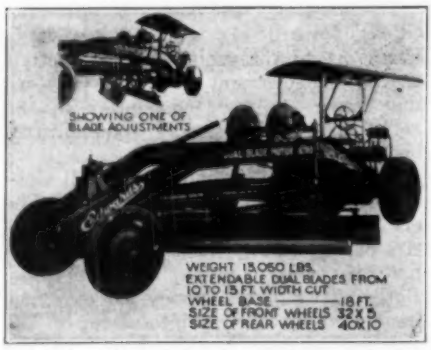
Motorist Receives Special Returns.—The motorist, while contributing largely, receives a dividend in lower operating costs, to the extent of two or three cents per mile.

Add the recreational benefits, consider, even partially, the economic returns, and I think that no one can return other than an affirmative answer to the question propounded.

Our highway finance structure is sound. It is necessary. And it is paying everybody.

Edwards Announces Improved Motor Patrol

The C. D. Edwards Manufacturing Company, of Albert Lea, Minnesota, had on exhibit at the Good Roads Show at Cleveland something new in motor patrols which was built primarily be-



The New Edwards Dual Blade Motor Patrol

cause of the demand for such a machine to maintain roads and remove "corduroy" which is so common in roadbeds today.

On account of patent rights, they are the only company manufacturing a dual blade motor patrol and it is claimed by their company that the advantage of such construction is the ability to remove and keep the road free from "corduroy."

The 10-20 size McCormick-Deering Tractor is used in conjunction with the 15-30 size automobile steer front axle with 32x5 front wheels and 40x10 either solid tread or dual tread rear wheels. The frame is made of 10 in. channel steel weighing 25 pounds per running foot which gives the machine a most rigid backbone. The worm and gear are mounted so as a direct connection is effective between the blades and worm gear assembly, thereby throwing all the load from the blades directly onto the worm gear. The hand wheels at the operator's platform simply turn the worm which is located at the center of the machine. The lifting gears (which are enclosed in oil tight cases) and the lifting arms are made of one homogeneous mass of metal, consequently, there is no possible chance of play between these two.

All wearing parts in the machine are fitted with bushings or adequate takeups. All parts subject to wear average from 100 to 500% larger in area than on any other Motor Patrol yet on the market.

By use of the wheel directly in front of the operator, he can raise or lower the front end of the draw bars which will allow the front or rear blade to cut as much or as little as desired, independently of the other.

It is claimed by the company that by cutting one-half of the load with the front blade and the balance with the rear blade, the machine has 80 per cent less tendency to vibrate than as though the whole load would be cut with one blade only. With dual blades, one blade acts as the wheel base for the other thereby preventing either the front or the rear blade from dropping in the low holes. Each blade is mounted rigidly to one heavy high carbon beam, thereby making it impossible for one blade to drop into low places without the other also doing the same.

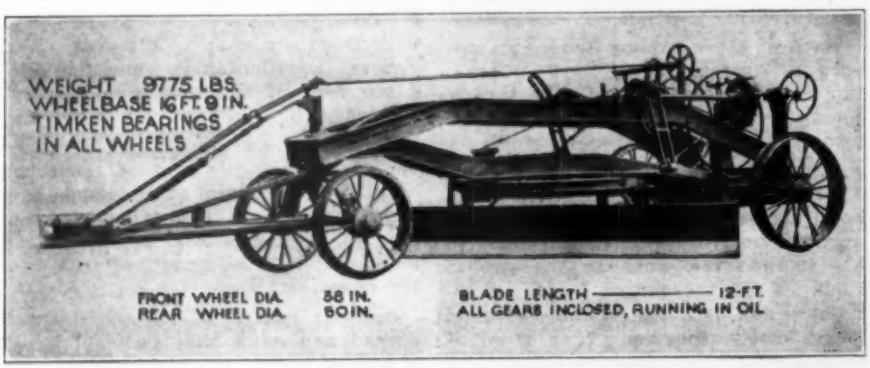
Both blades are always parallel and can be angled at 45 deg. either to the right or left. The blades are also extendable so that the machine can cut a ten-foot swath or a thirteen-foot swath just as the operator desires. It is recommended in the spring of the year that the two blades be placed one behind the other when the heavy work on the roads must be done and after the roads are put in better condition the blades are extended to cut any width of roadbed desired, up to thirteen feet, in one cut.

The blades can be also tilted independently of the other thereby allowing the front blade to do the cutting and the rear blade to do the smoothing or troweling. Or, in case the operator wishes both blades to be tilted forward to do troweling only, the adjustment can be easily obtained by two simple adjustments.

While the improvements as are found in the Edwards Motor Patrol are new, the application of two blades as a maintenance machine is not. There are over fifty motor patrols of this type operating in the state of Texas at the present time. Also the State Highway Department of Washington has adopted as their standard maintenance unit, the two-blade machine which is, in their case, an application pertaining to horse-drawn equipment.

It is also pointed out that by using an extra large lifting gear which is twenty-four inches in diameter, the teeth of this gear are not only large in size to stand wear but also give enormous leverage on the blade to hold it in position. By exerting only one pound pressure pull or push on the hand wheel the blade assembly will run either up or down indicating an excellent balance of the blade and fine workmanship.

The weight of this machine with cab and without scarifier as is shown in the photograph is 13,100 pounds. The blades will extend outside of the wheels on either side forty-six inches.



The New Edwards 12-ft. Grader

View of the Gettleman Snow Plow on Small Truck

Heil Announces Details of New Plow

The Gettelman High Speed Plow manufactured and sold by the Heil Co. is now being placed on the market. This snow plow is the result of years spent in the solving of the highway and street snow removal problem, and it is claimed to be the lightest, fastest, and strongest trip blade plow now manufactured. Tests are said to show that it will operate in dry snow at a speed up to thirty-five miles an hour. The plow will work well at both slow or high speeds, throwing the snow as far off the roadway as possible, thus keeping down the height of the banks. It can be installed on any truck of two tons' capacity or larger in two hours' time, and if the attachments are in place, the plow may be removed or attached in several minutes, according to the manufacturers. The scraper blade is 38 inches high and is built in 9 or 10-ft. lengths. The extra high blade keeps the driver's vision clear when the truck is running at high speed. In the truck cab a wheel on the end of the control rod provides means of raising the plow to a carrying position.

The plow has three positions relative to the road, one a predetermined position to the right, one to the left and a position square across the front of the truck. This latter position is used when bulldozing the snow at road intersections. The first two positions are secured through the use of tubular push arms attached to the front axle, with a universal axle attachment, and the arms telescoped so that the angle of the blade may be adjusted to either position.

One of the distinctive features of this equipment is the tripping action of the blade. It safeguards the blade when traveling over small obstructions such as rail tracks, stop boxes and manholes in the street. When the blade hits an obstruction it pivots on the push arm attachment toward the horizontal position, until it passes the object. Springs then bring it back to the operating position.

Another feature is the offset of the blade in respect to the motor truck. The discharge edge extends one foot farther beyond the wheels of the truck than the inner edge. This arrangement is said to minimize the side draft because the pressure of the snow on the offset inner portion of the blade throws the pressure line to the rear of the steering knuckle of the front wheel of the truck, with the result that the truck keeps nosing toward the side on which it is discharging snow instead of away as is usually the case. The truck can also stay on the concrete or hard part of the road and still have the plow reach beyond the edge of the roadway. It also allows heavy duty chain drive trucks to plow close to the curb without getting ice and snow into the driving chains.

In operating the plow little or no spring tension is required. This is said to insure positive operation of the trip mechanism, and enable the blade to cut hard packed snow more efficiently, as only enough tension is required to counteract the trip action.

The wearing parts are reversible, which assures the most use of the cutting blades, and in the event of mishap or damage, they can be readily disassembled part by part and straightened without the use of expensive tools.

The plow, although essentially a snow plow, can be used for bulldozing dirt into a gas main excavation instead of using many men or a back filler.

When the plow was tested by the City of Milwaukee and the county of Milwaukee, it was found that it takes less power for the work it does, weighs less, has keener cutting ability and greater freedom from repairs than any other plow they used, according to the manufacturers.

Buda Produces Diesel Engine for Contractors

The Buda M.A.N. Diesel engine is stated to represent the latest development in light-weight high-speed Diesel engines for motor trucks, pavers, power shovels, cranes, pavers, and other construction equipment. It is manufactured under license from the Maschinenfabrik Augsburg-Nurnberg A. G. of Germany, commonly known as the M.A.N. Company, in whose shops Dr. Rudolph C. Diesel built his first engine over 30 years ago.

Possessing all the operating features of heavy duty gasoline engines, the Buda M.A.N. requires practically the same space and has the added advantage of exceptionally low fuel cost. Compressorless construction—that is, the system of injecting fuel into the cylinders without the aid of compressed air—is one of the main reasons for the lightness of this engine. The omission of an air compressor also simplifies operation and servicing.

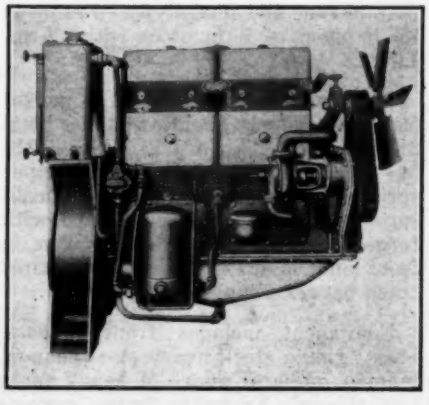
The Buda M.A.N. 6x8 high-speed Diesel engine is of the solid-injection, four-cylinder, four-stroke-cycle type, and develops 92 brake horsepower at a normal speed of 1,000 revolutions per minute, and is arranged for ledge or three-point mounting. Bell housing size, SAE No. 0 or 00. Fuel having a Baume gravity of approximately 26 to 38 can be used.

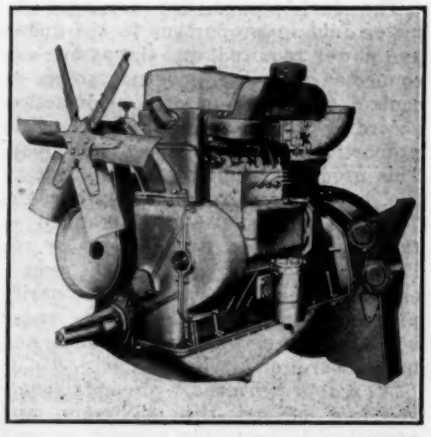
Owing to the simple construction, the method of fuel injection, the lubricating system and the accessibility of parts, a minimum amount of attention is required when the engine is running and all operating instructions can be acquired quickly and easily, according to the manufacturers.

The crank-case and the cylinders are made of cast iron, with removable cylinder sleeves. The fly-wheel housing is made of cast iron, and is removable.

Cylinder heads are cast in pairs and are detachable. The inlet and exhaust valves are located in the cylinder heads, and are operated by rocker arms and push rods actuated by a camshaft which is assembled in the crank-case. Rocker arms and push rods are enclosed to prevent dirt and grit coming in contact with them.

Each cylinder is fitted with two injection nozzles, one on each side of the cylinder. The arrangement of nozzles gives simplicity of cylinder-head construction, and permits, without difficulty, the largest possible area for the intake valves. The nozzles can be dismantled by simply loosening two nuts, and the time required is about the same





Two Views of the New Buda M.A.N. Diesel Engine Designed as Power Plant for Motor Truck or Contractors' Equipment

as that taken to remove a set of spark plugs.

The fuel-pump assembly is positively driven by a gear in mesh with the timing-gear train. Independent fuel pumps for each cylinder are grouped in a common housing, and deliver fuel in proportion to the load through the action of overflow valves.

The governor, which operates directly off the fuel pump, is built as an integral part of the pump, and is arranged so as to make it impossible for the operator to change the maximum rated speed. The cooling system resembles the conventional type that is found on the industrial gasoline engine. The water pump is of the impeller type, and is driven from the timing-gear train.

The lubrication system is the force-feed, dry-sump type, and includes pressure to the piston pins and to the rocker arms operating the overhead valves. A well-designed filter is incorporated in the oiling system.

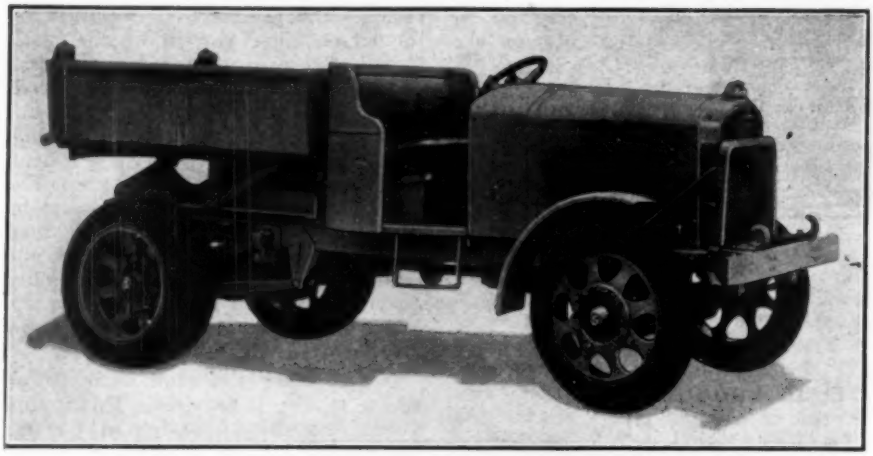
The engine is designed in accordance with the airless fuel injection principle (spray atomization); that is, the fuel is injected into the combustion chambers by means of pressure from the fuel pumps, and without the use of compressed air or pre-combustion chambers. There are no hot spots, hot surfaces, or plugs which have to be previously heated or inserted. The airless injection system makes it possible to start a cold engine in a short time, and without any special preparation. In this connection, simplicity of operation is introduced by constructing all fuel injection valves of the open nozzle type, thus dispensing with check valves and other movable parts.

A special design of filter is assembled as part of the engine for filtering the fuel oil. The design is such as to prevent impurities reaching the fuel lines or plugging up the nozzles.

The Buda M.A.N. Diesel engine operates on the four-stroke-cycle principle. Fuel is injected directly into the combustion chambers, and a constant volume of air is taken into each chamber with the intake stroke.

The fuel pumps are arranged to meter fuel in proportion to the speed and power required, and the pumps are connected with the governor so as to control the duration of fuel injection according to a specific crank angle proportionate to the speed and load. This produces about the same effect as the butterfly valve in a carburetor. The fuel pumps also are arranged so that injection can be advanced or retarded according to speed, which eliminate the high stresses ordinarily produced in Diesel engines under acceleration, and insures smooth and quiet operation, it is claimed.

A safety governor prevents overspeeding beyond the maximum, and provision is made for manual as well as governor regulation.



New Type of Selden Road Builder Truck

Selden Roadbuilders Are Announced at Good Roads Show

At the Good Roads Show in Cleveland January 9-14, Selden Truck Corporation, of Rochester, N. Y., exhibited two roadbuilder's trucks which embody features that are said to provide maximum haulage at minimum costs.

Model 2X, the 2½-ton size, is built in 120 in. wheelbase to provide extremely short turning radius. Tires are pneumatic 34x5, duals rear. Engined with a 6-cylinder 65 H.P. having 7-bearing crankshaft, all bearings being 2⅜ in. diameter. Stromberg carburetor is used. Air cleaner is regular equipment. Ignition is furnished by high tension magneto. Gasoline tank of 10 gal. capacity is mounted under the cowl. Transmission is unit with the engine and is of the selective gear type with 4 forward and one reverse speed, having special low gear ratio in first and reverse. Clutch is the multiple disc, dry plate type. Propeller shafts are tubular with grease-tight metal universal joints.

Rear axle is full-floating double reduction type designed for 50 per cent overload. Road clearance with 34 in. tires is 10¼ in. Radius rods are tubular with ball and socket ends. Steering gear is cam and lever type. Frame is 5¾ in. deep, of ¼ in. stock with 3½ in. flange.

Springs are semi-elliptical of silico-manganese steel. Front are 41 in. long, 2¼ in. wide. Rear are 52 in. long, 2½ in. wide with semi-elliptic helper springs mounted on top of main springs. Wheels are spoke type with forged steel spokes. Tread is 59 in. in front and 65 in. in rear. Front tires track between dual rear tires.

Equipment includes front fenders, heavy gauge steel, heavy steel channel bumper, radiator guard of heavy angle iron strongly braced to frame, motometer, steps, jack, set of tools, oil pressure gauge, hand horn and open seat with comfortable cushions.

Model 4X is a 4-ton size with a 6-cylinder 72 H.P. Engine. Wheelbase is only 130 in. to provide minimum turning radius. Tires are pneumatic, 34x7 single front and dual rear. Ignition is furnished by high tension magneto with impulse coupling. Carburetor is Stromberg. Gasoline tank is 20-gal. capacity is mounted under driver's seat. Fuel feed is by vacuum tank. Transmission is unit with power plant of selective sliding gear type, having 4 forward speeds and one reverse. Clutch is the multiple disc, dry plate type.

Propeller shafts are tubular with large grease-tight metal universal joints. Rear axle is full floating, double reduction type designed for 50 per cent overload. Road clearance with 34x7 tires is 10¾ inches. Service and emergency brakes are internal expanding on rear wheels. Radius rods are tubular with ball and socket ends. Steering gear is the cam and lever type.

Frame is pressed steel channel, 7 in. deep, ¼ in. thick with 3½ in. flange. Springs are semi-elliptic of silico manganese steel. Rear spring has semi-elliptic helper springs mounted on top of the main springs.

Wheels are spoke type with forged steel spokes and are guaranteed for the life of the truck. Tread in front is 62 in., rear is 65 in. Front tires track between dual rear tires.

Equipment includes front fenders of heavy gauge steel with cast brackets, heavy steel channel bumper, radiator guard of heavy angle iron strongly braced to frame, open seat with comfortable cushions, air cleaner, motometer, steps, hand horn, oil pressure gauge, jack and set of tools. Electric lights and starter will be furnished at a small additional cost.

Both chasses can be equipped with hand operated dumping equipment or power operated dumping equipment, whichever the purchaser prefers.

Gravel Roads in Northern Michigan

A Paper Presented Sept. 28 at Convention of Canadian Good Roads Association

By A. L. BURRIDGE
Division Engineer, Michigan State Highway Department

THE state gravel road system of northern Michigan, which compares with your provincial roads, constitutes a mileage of 1,600 miles, only 250 miles of which is hard surfaced, the remainder being gravel, and between 3,000 and 5,000 cars per day pass over these gravel roads in the summer, and if it is necessary for us to give the people satisfactory roads, it is necessary to do intensive maintenance.

Gravel as a material for surfacing highways is available for use in most of the states and provinces of the North American continent. Undoubtedly more miles of highways are surfaced with this material than any other. Its cheapness and the fact that it can be found within an economic haul to many road construction projects demands its use.

Two Classes of Gravel Road.—There are many different kinds of gravel, but there are few instances where this material with proper crushing, screening and with the addition of the proper amount of binding material cannot be used. The Michigan State Highway Department constructs two kinds of gravel surfaced roads, the widths of same varying from 12 to 18 ft. The Class "A" road is placed to a depth of 5 in. compacted and consists of gravel passing through a 1-in. screen and containing 70 per cent pebbles. The Class "E" road consists of two courses, the bottom course of 5-in. compacted gravel and the top course of 3-in. compacted gravel.

As soon as the traffic on these gravel road surfaces reaches an average of 500 or more vehicles per day, we find it necessary to treat the same with some kind of dust layer or bituminous material. In the Northern District of Michigan the material used for this work consists of calcium chloride, refined tar and cut-back asphalt. Where the traffic demands a pavement we are also using these gravel roads as a base and surfacing the same with a 2-in. asphaltic concrete top, using about 500 tons of binder per mile to strengthen the edges and bring the old road to an even cross section with the 2-in. crown.

It so happens that a considerable part of our trunk line state roads were constructed by counties and townships from 8 to 15 years ago. It has been necessary for us in many cases to take these roads over and improve them with our maintenance organizations. As these roads in many cases were constructed from bank run gravel which contained oversize stone and in most instances very little binder, it has been our problem to get these surfaces in condition for the traveling public. We felt that traffic was entitled to a smooth, even surface on all our trunk lines, and instead of making excuses that the road was old and worn-out and needed rebuilding, we went to work on these surfaces and put them in shape so that they could be used with comfort by those who wish to travel in our territory.

The method I will now describe includes the treatment of this mileage as well as our state constructed trunk lines.

Before a road is treated with any surfacing material it should be brought to an even cross section, thoroughly consolidated and the proper drainage established. We find ¼ in. to the foot crown is sufficient. Excessive crown will concentrate your traffic to the center of the road. Concentrated traffic makes ruts. Even distribution of traffic over the entire width of your road prolongs its life and cuts your maintenance costs many times.

Effect of Crown on Spread of Traffic.—We have taken traffic census on some of our 18-ft. roads on which the traveled surface was divided into three 6-ft. strips. We find on a concrete road with a 2-in. crown that 51 per cent of the traffic use the center 6 ft. and 24 per cent use the outer 6-ft. strip. On a 2-in. crown gravel, we find that 60 per cent of the traffic use the center strip and 20 per cent use the outer 6-ft. strip. On an 8-in. crown we found that 66 per cent used the center strip and 17 per cent used the two outer 6-ft. strips. This investigation not only shows that crown will concentrate traffic but it also teaches us that we need more intensive maintenance of the center of our road than we do on the edges.

Use of Clay Binder.—Loose gravel also causes ruts and the concentration of your traffic. This gravel should be bound up and consolidated into the surface. This can be done by adding clay evenly mixed to the loose gravel until the same contains from 8 to 12 per cent of the same. We find it takes an average from ½ to 3 cu. yd. of clay per 100 ft. of road to furnish binder for this loose gravel. The amount of clay used depends upon the depth and kind of gravel. It is very necessary that careful supervision be given this work for an excess of clay is dangerous and in many cases will ruin the road. The safest way to place clay on the road is to spread the same along each edge of the road and when the same is completely dry, thoroughly mix it into the gravel with a grader blade or harrow.

I wish to lay special stress on the mixing of this clay for if it is allowed to get in bunches it will have a tendency to flatten out and pancake on the surface of the road which eventually will cause bumps and ruts and make the riding qualities of the surface very uneven and hard to maintain. After the traffic has used the road for a few days if any loose gravel remains on the surface it should be bladed to the side and left there. A very light coat of buckshot or pea gravel can then be added and the surface is ready for the calcium chloride treatment. Five tons of calcium chloride are then applied to every mile of road for the first application and later in the season such additional amounts as may be required are applied to prevent the slightest occurrence of dust.

Application of Calcium Chloride.—We find it desirable from the public standpoint to treat all of our mileage at one time and this year we shipped 110 cars from the plant in three trainloads in one day and three days after this chloride was all on the road and ready to be used by the public. In applying this chloride we use a 3½-ton truck to which is attached the standard chloride spreader or drill. We find it desirable to have these drills equipped with pneumatic tires carrying a pressure of about 20 to 30 lb. It is very desirable in order to get the greatest benefit from the chloride treatment, to have the same very evenly distributed upon the surface and this equipment allows us to accomplish this purpose. This 3½-ton truck is kept supplied with chloride by smaller trucks which bring the material from the cars to the different points on the road where the same is transferred from the smaller trucks to the distributor truck. After the calcium chloride has been on the road for one day we immediately start floating our surface with a tractor grader or truck with spring blade attachment. The road is first floated out and the blade is so set that it cuts the surface just enough to eliminate any bumps that may have come into the road. This gives us a very small ridge of calcium chloride material which can be floated back on the road within the next day or two or whenever same is necessary. We have found in some cases that it has not been necessary to float when

the road is carrying about 1,000 vehicles per day more than once a week, but we do insist that our patrolmen float their roads after each rain, but in doing so, by all means do not bring in any of the loose dead material which might be on the edge of the road. The dead material which was originally floated out before the road was treated should never be touched or brought back on to the surface during the summer season, but it is desirable that this material be floated back on the road during the late fall, and if possible, the same consolidated into the surface.

Treatment With Tar.—In surface-treating our roads with bituminous material, we prepare the surface in about the same way as we do for calcium chloride treatment. The only great difference is the fact that we can allow some oversize stone in the surface when the same is treated with bituminous material. After this surface has been thoroughly swept with a power broom, we apply about ¼ gal. of material to the square yard on the surface. This material is heated to a temperature of 100 deg. and the same is pumped into a pressure distributor mounted on a motor truck where the same is applied to the road. After this application has been allowed to lay on the road for two or three days until the same has penetrated the surface, a second application is made of about ¼ gal. to the square yard, and this is covered with pea gravel or stone chips. We find it takes about 25 lb. of stone chips or pea gravel per square yard of road, but this will vary considerably, depending upon the roughness of the surface. After the stone chips have been placed, traffic can then use this road, but it is desirable wherever possible to keep the same closed for about two days as this will eliminate any picking-up or smearing of cars with tar. As soon as traffic starts using our tar surface, we place a patrolman on this road and have him repair any depressions or places that might pick up in the road. We find that this is the time to do intensive maintenance work on this type of construction, and by doing this the first two or three weeks that the road is used, it practically relieves us from any maintenance throughout the rest of the season.

The next year after this treatment has been made we put on a hot treatment of about ¼ gal. per square yard, place the necessary stone chips or pea gravel to absorb any tar which remains on the surface, and then this road is in a condition to give us service from three to five years without any more treatment. We are using this treatment on the roads that carry from 1,000 to 3,000 vehicles per day during the tourist season.

Construction of 2 in. Asphalt Top.—Where the traffic has exceeded this amount, we are taking these gravel surfaces and placing upon the same a 2-in. asphalt top with the necessary binder course which runs about 500 tons to the mile. If the gravel surface has not been previously treated with bituminous material, the same is brought to about a 3-in. cross section and treated with from ¼ to ⅓ gal. of material per square yard of road. The black base is then placed to a width of 19 ft., and it is used to strengthen the edges and take out any depressions in the road surface. We then place upon this a 2-in. asphalt top 18 ft. wide. This top material and binder is prepared in the usual types of asphalt plants and is transported to the road by 3½-ton trucks. The same is laid in the usual method as governs the placing of all sheet asphalt surface. The average cost of these three types of resurfacing varies considerably and their use is governed more or less by the traffic and the condition of the road upon which they are placed.

Cost of Surface Treatments.—Calcium chloride costs us about $30 per ton applied on the road. In case a 10-ton application is necessary, this work would cost about $300 per mile. The first year's bituminous treatment costs us from $1,000 to $1,200 per mile, and the second year about $500 per mile. The 2-in. asphalt concrete top, 18 ft. wide, is costing between $8,000 to $11,000 per mile, and the black base for the same is costing about $3,000 to $4,000 per mile, making the total cost for this surface about $13,000.

Personnel Important Factor.—The methods I have described to you have been successfully used in the Northern District of Michigan for the last two or three years, and the most important factor in their success has been the personnel of our organization which has accomplished this work. As engineers, we spend a great deal of time in the inspection of materials and in theories of doing work, but you seldom hear much discussion on organization or personnel. A road building organization must consist of men who are fitted to perform efficiently the different tasks to which they are assigned. Road building has ceased to be a pastime for the employment of labor during the slack time of the year, but it is a business which demands trained, executive ability to direct the same; and skilled, efficient laborers to perform the many duties which enter into the construction program. All the personnel of this organization should feel secure in their positions as long as they perform their duties in an efficient and satisfactory manner. Political preference should not be allowed to enter into any organization and a man should hold his position only as long as he is able to "produce the goods." The executive end of this organization should make every man feel that he is a necessary part and that the duties he is performing are important. A pride and interest in the work should be cultivated and wherever possible, full time employment should be given so that the efficiency of the organization will continue from year to year. The greatest waste of the taxpayer's money has not occurred so much through dishonesty as it has through inefficiency, and I believe it is important that those in charge of the road building operations should give this matter much more serious thought and attention.

Cost of a Bituminous Mat

By FORREST R. JONES
Knoxvillle, Tenn.

During 1927 the State Highway Department of Tennessee constructed a bituminous mat on 9½ miles of the road from Etowah through Athens to the Polk County line. The mat was 16 ft. wide and about ¾ in. thick. The labor cost was less then 0.7 ct. per square yard, this item covering the work of the 14 men on the job.

Crushed copper slag, about one-third heavier than crushed limestone, was the hard material put into the mat to the amount of 5401.25 tons, and 76803 gal. of tar-oil were used.

Of the crushed copper slag, about 27 lb. per square yard were spread first, and then on that a layer of about 94 lb. of the same material per square yard.

The first coat of tar-oil amounted to about 0.4 gal. per square yard, and the second coat of the same tar-oil to about ½ gal. per square yard.

In the following table, the rental is the charge made by the Division of Equipment of the State Highway Department for the use of the equipment enumerated later.

Itemized Cost of Dustless Mat 16 Feet Wide, 9.5 Miles Long and About ¾ in. Thick.

	9.5 Miles	One Mile	One Sq. Yd. Cts.
Labor	$ 621.05	$ 65.37	0.6964
Rental	581.92	61.25	0.6526
Gasoline & Motor Oil	246.30	25.93	0.2762
Tar-Oil	9,345.62	983.75	10.4803
Crushed Slag	9,311.92	980.20	10.4425
Totals	$20,106.81	$2,116.50	22.5480

The cost of the road material (crushed slag and tar-oil) was $18,-657.54 while the cost of putting the road material into the mat was $1,-449.27 including rental: accordingly about 92.8 per cent of the cost was for road material, and about 7.2 per cent was for rental plus the work of putting the material into the mat.

The equipment used was one of the oiling units of the State Highway Department of Tennessee and consisted of:

1—Broom Sweeper.
1—Blower for removing dust from the road.
1—Grader, Wehr 1-man type, motored.
1—Roller, Galion 5-ton.
1—Fordson tractor.
1—Oil distributor, Kinney.
1—Loader, Barber-Greene.
3—Liberty trucks, 5-ton, each having a Cascade valve-gate spreader bolted to the dump body.

S. M. Williams Joins Staff of A. G. C.

Becomes Manager of the Engineering and Construction Division of National Contractors' Association

S. M. WILLIAMS, one of the most prominent men in the highway and motor vehicle industries, has been appointed Manager of the Engineering Construction Division of the Associated General Contractors of America. His headquarters will be in Washington, D. C., and his specific duties will be the development and promotion of matters of benefit to engineering construction, including highways, public works and railroads.

For the last 16 years Mr. Williams has been active in development and promotional work—first—in highway programs and later with the construction. His interest in highway improvement has been national and he has actively participated in better highway programs throughout the entire country. In his advocacy of good highways, he realized their influence for the good of the country, but he also foresaw how the building of good highways would increase the demand for motor vehicles. As far back as 1912 to 1915 he urged the motor vehicle industry to engage in educational work to promote the building of good highways. He urged an appropriation for a five year period of a small amount of the then expenditures in so called national motor vehicle advertising, of which at that time, a large circulation covered territorries which later developed were slow in highway improvement.

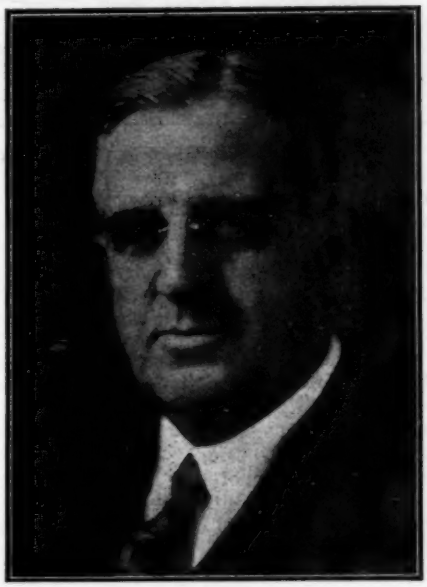
In January 1915 the Motor Vehicle Industry advised Mr. Williams that such a campaign would be radical to anything they had ever undertaken and besides they did not have the money, notwithstanding the industry was at that time spending approximately five million dollars per year in national advertising.

In February 1915 as general sales manager of the Garford Motor Truck Co. of Lima, O. Mr. Williams inaugurated an individual campaign for better highways announcing at the same time that any time the motor vehicle industry decided to become active in the promotion of better highways he would bury his individual activities and join with the industry in a united effort.

One of the first campaigns with which Mr. Williams cooperated was one in Delaware for a one million dollar bond issue. Charles M. Upham, now director of the American Road Builders Association was in charge of the campaign and later wrote Mr. Williams that his cooperation was largely responsible for the success of the campaign.

During 1915 to 1917 Mr. Williams was active, and partly responsible, for the success of a number of highway programs throughout the country.

Late in 1918 the manufacturers of equipment and materials used on the highways, and in their construction desiring to offer to the government the united experience and cooperation of their industries, formed the Highway Industries Association with Mr. Williams as its president. In order that his work might be entirely impartial as between any manufacturers Mr. Williams resigned his position with the Garford Motor Truck Co. on January 1st, 1918, and until September, 1921, he contributed his entire time, without remuneration to the work of the Highway



S. M. Williams

Industries Association and later to the Federal Highway Council.

Along with other organized efforts the Highway Industries Association saved considerable highway construction and maintenance throughout the country that might have otherwise been a total loss.

Early in 1919 the Highway Industries Association activities were taken over by the Federal Highway Council. The Council under the direction of Mr. Williams as its chairman was instrumental in assisting many contractors in securing car equipment for shipment of materials. It was also active along with the Association of State Highway Officials and other agencies in advocating a continuance of Federal Aid, and the building of highways to definite inter and intra state systems. The Council assisted and in some cases directed the campaign for large highway bond issues in a number of the states.

In September 1921 Mr. Williams returned to the motor truck industry and as Vice President of the Autocar Sales and Service Company of Ardmore, Penn. he began the organization of a department for the sale of motor trucks to the construction industry. His former experience in the motor vehicle industry and in Washington gave him an understanding of the method of awarding contracts for public construction and the result therefrom.

He and his associates realized an obligation as a benificiary of road construction of cooperations with those interested in building confidence and stability into the construction industry which meant creating in the mind of the public and the public official that the low bid was not always to the best interest of the public and that there was justification for definite consideration of all of the bidders qualifications before awarding the contract. In 1922 he began urging the use of questionnaires by State Highway Departments and others having to do with the award of public construction contracts to determine the qualifications including responsibility, experience and integrity of bidders, before the award of contracts.

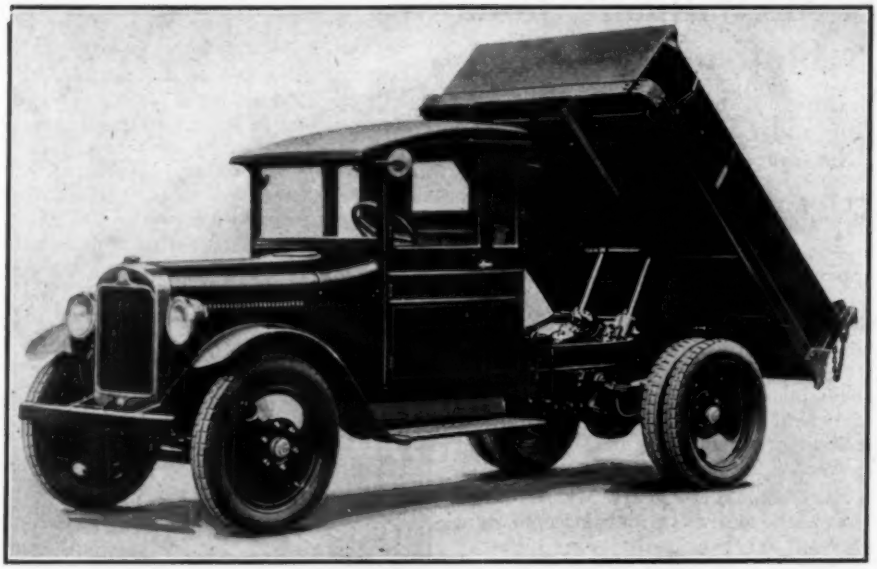
A conference of committees representing the state highway officials, architects, consulting, civil and mechanical engineers, Society for Municipal Improvements, manufacturers of construction equipment and representatives from the construction divisions of the United States Treasury, War and Interior Departments, meeting in Washington, D. C. on Feb. 16th, 1925 unanimously recommended by resolution "that both public and private owners adopt a comprehensive uniform questionnaire covering skill, integrity and responsibility that will be submitted by all contractors bidding upon construction work." A committee of which Mr. Williams was named chairman, was appointed by the chairman of the conference, Gen'l R. C. Marshall, Jr. The Committee was known as the "Committee on Uniform Question naires" and in addition to Mr. Williams its personnel consisted of W. H. Connell, Deputy Secretary of Highways and Engineering Executives Pennsylvania Highway Department; L. A. Bouley, Director of Highways and Public Works of Ohio; I. P. Jones, Secretary State Highway Department of Delaware, representing the State Highway Departments; Morris Knowles, President Morris Knowles Inc., Consulting Engineers, Pittsburgh, Penn., representing the American Institute of Consulting Engineers; F. L. Cranford, President F. L. Cranford Co., General Contractors; Ward P. Christer, Engineer General Contractors Association representing the Associated General Contractors; J. S. Langthorn, President Langthorn & Smith Engineers and Contractors, New York City, representing the American Society of Civil Engineers; and Keith Compton, Director of Public Works of Virginia, representing the American Society of Municipal Improvements. In undertaking its work the committee invited and received cooperation from the Committee on Bet-

ter Underwritings of the Surety Association, the National Association of Surety Agents and the Clearing House Section of the American Bankers Association.

On May 22nd, 1925 the "Committee on Uniform Questionnaires" reported back to the conference definite recommendations which were unanimously approved and are what is now known as the "Standard Questionnaires and Financial Statement forms of the Joint Conference on Construction Practices.

Since the approval of the questionnaires Mr. Williams has been active in promoting their use. In addressing a Construction Problem Construction meeting of the American Road Builders Association in 1926 A. R. Hirst former State Highway Engineer of Wisconsin said "There has been a quite sustained effort to improve the situation by providing for the real qualification of bidders, either in advance of the bidding or before an award is made. Mr. S. M. Williams of the Autocar Company has probably done more than any one man to promote this much needed reform and a considerable advance is being made."

As a recognition of Mr. Williams activities for better highways, and the construction Industry he was recently reelected a director of the Highway Industries Association an organization of manufacturers and exhibitors of construction equipment. At their recent convention in Cleveland, Ohio, he was elected a director of the American Road Builders Association.



The Same Truck as Equipped with the Hydraulic Type Dump Body

Graham Bros. Announces New Roadbuilder

Sturdiness, compactness and unusual ability are claimed for the new 2-ton road builder truck built by Graham Brothers, the truck manufacturing division of Dodge Brothers, Inc. Interesting features are the 6-cylinder engine, 4-speed transmission, 3 optional rear axle ratios, 4-wheel Lockheed hydraulic internal brakes, 114-in. wheelbase and a frame of 7⅛ in. depth. The rated speed is 35 miles per hour while it is claimed that this truck will pull its rated load anywhere that its tires can find traction.

The engine is a basically Dodge Brothers Senior 6-cylinder; bore 3¼ in.; stroke, 4½ in. An L-head type, the engine develops 45-50 brake horsepower in actual service. The 7-bearing crankshaft is inherently balanced. It is completely machined and has a total main bearing length of 11 in. The oiling system is of the force feed type, delivering oil under pressure to all main, connecting rod and camshaft bearings as well as to the front and silent chain. The pistons are aluminum alloy with Invar Metal struts, permitting their fitting with minimum clearance. Exhaust valves are one-piece silchrome steel while the intake manifold has a hot spot. Ignition is by battery and distributor and an electric starter and generator is standard equipment.

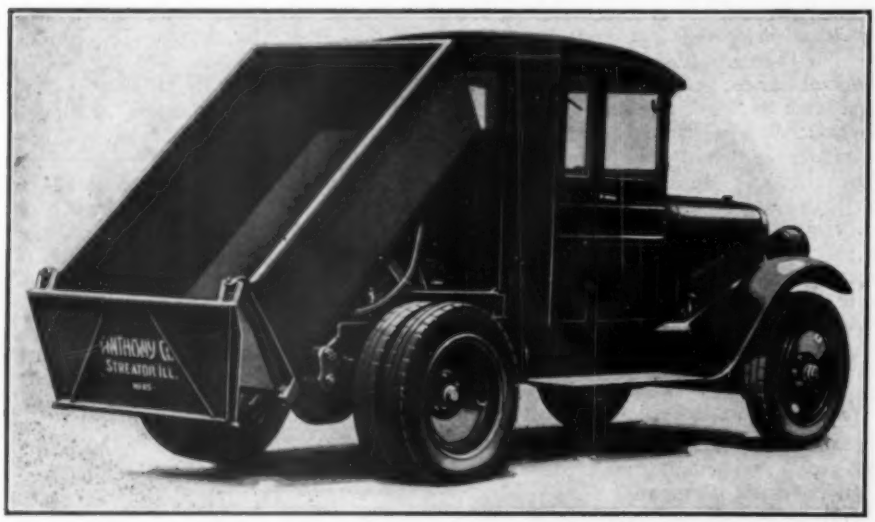
The clutch is single dry plate type while the 4-speed transmission has ball bearings on the mainshaft and roller bearings on the camshaft. Gears are alloy steel varying in width from 27/32 in. to 1 3/16 in. The transmission low ratio is 6.5:1. The unit power plant is used. The spiral bevel gear rear axle has a straddle-mounted pinion and dual Timken roller bearings at the wheels. A cam and lever type steering gear and roller bearings at the steering knuckles insure easy steering.

The maximum depth of the frame is 7 1/6 in. The material is ¼ in. thick and the maximum width of the flange is 2⅞ in. The rear frame cross member is of a special tubular type while the frame is dropped behind the rear axle for convenience in the use of dump bodies.

The 4-wheel Lockheed hydraulic brakes are, of course, inherently equalized. The diameter of each drum is 16 in. and the brake lining 2¼ in. wide, the total braking area being 300 sq. in. The hand brake operates on the propeller shaft.

The front tires are 32x6, rear 34x7, pneumatics only. The list price quoted by dealers includes front bumper, nickel-plated radiator shell and filler cap, front fenders, front running boards and splash shields, tire carrier, electric head, tail and stop lights, electric horn, and complete tool kit. 34x5 or 32x6 pneumatic tire equipment, dual at rear, is also available, steel disc wheels being supplied with dual tires are used. Two standard dump bodies are offered —a gravity and a hydraulic type, both 1½ cu. yd. capacity.

Graham Brothers build commercial cars and trucks of five capacities: ½-ton, ¾-ton, 1-ton, 1½-ton and 2-ton with specially designed bodies to satisfy the requirements of over three hundred trades and vocations.



New Graham Bros. Road Builder with Gravity Type Dump Body

Paving Work in Ohio During 1927

More than 1,800 miles of improved highway have been under construction or have been completed by the Ohio State Highway Department during the period from Jan. 1 to Oct. 20.

More traffic-bound macadam roads have been completed than any other type.

Traffic-bound macadam, highway engineers pointed out, is gravel, slag or crushed limestone, placed on the road surface and "bound" by traffic.

Of this type of road 175 miles were contracted for at a cost of $352,203, of which 117.9 miles have been finished, costing $231,868. In addition, however, the department itself has constructed about 600 miles, at an average cost of about $3,000 a mile, according to Chief Engineer Harry J. Kirk.

In all, about $2,152,203 worth of traffic bound macadam (gravel, slag or crushed rock) has been built or is under construction.

Since the first of the year, the department has had a total of 1,275 miles of road under construction by contract and not including the 600 miles it built itself. Of this 1,275 miles, a total of 593 miles has been finished, for which $8,768,970 has been paid.

The total cost of the 1,275 miles, the figures showed, will be $23,228,781.09, of which amount $8,768,970.44 has already been paid.

This, however, includes 105 bridges, for which contracts were awarded, totaling $2,984,630. Of these, 50 contracts have been completed and $973,216.64 paid, leaving 55 uncompleted contracts and $2,011,414 to be disbursed on them.

The amount still to be disbursed for the 682 miles of uncompleted highway totals $4,459,810.65.

The department awarded contracts for more miles of concrete than for any other type of expensive construction. A total of 316 miles, to cost $6,138,282, was contracted for during the period, of which 147 miles have been finished at a cost of $2,217,921.

Brick ranked next among the expensive types. A total of 82 miles was placed under contract, to cost $3,921,961. Nineteen miles have been finished, for which $794,663 has been paid.

The department contracted for 157 miles of bituminous macadam, to cost $4,015,683, and of this 70 miles has been finished at a cost of $1,750,359. Water bound macadam roads under construction totaled 102 miles, costing $2,115,994 and of this, 61 miles has been completed at a cost of $1,315,997.

In addition to this, the department gave or is in process of giving 247 miles of highway surface treatment at a total cost of $192,523. Of this, treatment on 117 miles has been completed, at a cost of $83,546.

The department also contracted for grading, bridge and culvert, and drainage construction on 128 miles of highway, to cost $1,914,282, of which 43 miles have been completed for $498,767. Contracts during this period were awarded for 23 miles of Kentucky rock asphalt, to cost $539,854, and of this, five miles have been finished, costing $133,330.

Warrenite bitulithic totaled two and one-half miles, all of which is finished, costing $148,532.

On 34 miles of road, the department contracted for guard rails and miscellaneous construction totaling $684,146, of which seven miles has been finished at a cost of $104,107.

Idaho Planning Road Program

Idaho's road program in 1928 may require an expenditure of $2,500,000 for construction, oiling and reconstruction.

Tentative figures, as discussed at a recent meeting of district engineers, called for $1,000,000 in federal aid and possibly $700,000 from state gasoline tax receipts, in addition to local funds available for co-operative projects.

The state hopes to spend $700,000 for oiling projects, while federal money will be used for oiling and reconstruction, it was said at the meeting, while it was found impossible to estimate available local funds at present.

No fixed budget has been made for maintenance. The bureau of highways' allowance this year has been but $250 a mile, but the department hopes to increase this to $300 next year, if funds permit.

Research Graduate Assistantships at University of Illinois.—To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 research graduate assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees (are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry. Applications for appointments to these positions should be sent by April 1, 1928 to M. S. Ketchum, Dean and Director College of Engineering and Engineering Experiment Station, University of Illinois, Urbana, Ill.

New Trade Publications

The following trade publications of interest to highway officials, engineers and contractors have been issued recently. Copies of them can be obtained by addressing the firms mentioned:

Special Cement.—The Atlas Lumnite Cement Co., Inc., 25 Broadway, New York City, has recently issued a folder showing the advantages claimed for their high alumina cement, Lumnite, for cold weather construction. In this bulletin they play up the fact that Lumnite gains strength within 24 hours equal to that gained by portland cement concrete in 28 days, and that the setting reaction liberates a sufficient quantity of heat to give still further cold weather protection. This bulletin discusses the properties of the material, gives directions for its use in cold weather, and illustrates a number of jobs that were done in winter with the aid of this special cement.

Rock Asphalt.—Alabama Rock Asphalt, Inc., Margerum, Alabama, in a booklet entitled "Better Roads and Pavements," tells how their Margerum limestone rock asphalt pavements offer long life, low maintenance costs, and low construction cost. Their rock asphalt is claimed to be similar to the Sicilian rock asphalt used successfully in Europe for many years, although Margerum is somewhat lower in bitumens than the Sicilian variety. Interesting claims are made for the material.

New House Organ.—The Trackson Company, 500 Clinton St., Milwaukee, Wis., has founded a new house organ, "Trackson Tracks," to be issued on the first of each month. This periodical will be mailed to salesmen, distributors, and dealers who handle their Trackson Full-Crawlers. Its purpose is to present information about new models of Trackson equipment, improvements, sales and service directions, and such performance records that may be reported from time to time.

Electric Hoists.—The American Hoist and Derrick Company recently issued a new booklet that is of interest to those using hoists for bridge construction, steel erection, concrete tower work or general contractors' use. This booklet brings out the reasons why this hoist is especially adapted to the various jobs, and in addition many advantages claimed for their hoists are treated in detail. A copy of this booklet will be sent upon request to the American Hoist & Derrick Company, 63 South Robert Street, St. Paul, Minn.

Gasoline Crane.—A new booklet was recently received from the American Hoist & Derrick Co., of St. Paul, that tells of the building of a gasoline crane with steam crane flexibility. The booklet states, "Locomotive cranes powered with gasoline engines have always had many good points, but have fallen far short of steam crane flexibility. Now in the 'American' Three-Speed Crane we offer a gasoline operated crane that has the range and flexible operation of steam." The booklet has interesting views of the machine and covers thoroughly many of the construction features, one page being devoted to Frictions, with further mention being made of general features, such as Revolving Mechanism, Gib Ring instead of King Pin, Revolving Deck, Car Body and Trucks, and Universal Joint Transmission. A copy of this booklet can be had by writing to the American Hoist & Derrick Co., 63 South Robert Street, St. Paul, Minnesota.

Tar Kettles and Torches.—Circular No. 12, issued by the Chausse Oil Burner Company, 1227 W. Beardsley Ave., Elkhart, Indiana, tells about their oil burning tar kettles and kerosene thawing torches. Specifications are given.

Road Maintainers.—The Hawkeye Maintainer Company, Waterloo, Iowa, in their new catalog are offering some interesting improvements in Road Maintainers. Principal among these, is the direct line of draft of all of their machines which is claimed eliminates blade chatter and produces a far smoother dirt or gravel road without disturbing the original grade. This new catalog points out many other features of the Hawkeye line of Maintainers which are offered in a variety of sizes and styles and are built by folks who have lived in the midst of the most difficult road maintenance situations. This catalog will be mailed to township or county officials or to road machinery dealers upon request. Simply address the Hawkeye Maintainer Company, Waterloo, Iowa, and mention Roads & Streets.

Compressors and Air Tools.—Ingersoll-Rand Co., 11 Broadway, New York City, have issued an interesting new folder illustrating the part played by their air compressors and air tools in highway construction. A wide line of equipment is illustrated.

Modern Equipment Plant.—Under this title, the Superior Supply Company, 1836-60 South Kostner Ave., Chicago, has issued a booklet illustrating their office and plant departments. It indicates that this firm is well equipped to render to the contractor the best sort of service.

Snow Loader.—George Haiss Mfg. Co., Inc., have issued a new catalog describing in detail the new Haiss Snow Loader. Complete specifications are given, and the advantages claimed for the machine are fully covered.

Posts.—An interesting and informative booklet on Special High Carbon Steel Posts has just been issued by the Sweet's Steel Company of Williamsport, Pa., which describes a new method for testing and determining the safety factors of steel posts. This unique method enables anyone contemplating the building of any type of wire fence to analyze wind loads and stresses and thus arrive at the scientifically correct size of steel post required for his particular purpose. Copies of this new booklet may be obtained free of charge by writing Sweet's Steel Company at Williamsport, Pa.

Pavers.—A catalogue of specifications has been recently put out by The Foote Company, Inc., of Nunda, New York. The new booklet describes the new features of the MultiFoote Paver for 1928. The contents are divided into nine sections which are indexed so that all section titles are visible at a glance. Power transmission is described in the first section, featuring the extensive use of Timken bearings. Section 2 is devoted to the power facilities, including an account of the new 6-cylinder Hercules engine, which is optional equipment for the 1928 pavers. Caterpillar traction is the subject of section 3, and in the next part the exclusive double cone drum and its fast, effective mixing are described. In section 5, which is devoted to the loading facilities and the raised center skip, a double page spread of photographs has been inserted. These photos show the Multi-Foote paver in operation in the various parts of the country. The remaining sections detail other features, such as power loading derrick, boom and bucket; banked lever control; automatic water tank, and batchmeter. Among the last pages of dimension tables, charts and other data, is a brief account of the new one-man folding top and the Foote transport trailer. Contractors and engineers interested may obtain the new "MultiFoote Specifications for 1928" either direct from the company or the Foote dealers in their locality.

Graders.—Copies of new catalogs and bulletins published by the Galion Iron Works & Mfg. Co., describing their new motor graders, have recently been received at this office. They include a new 16-page catalog on McCormick-Deering E-Z Lift Motor Graders and bulletins describing the Galion Cletrac, Twin City and Caterpillar powered Motor Graders. Bulletins have also been received describing the Galion Center Control Fordson and McCormick-Deering power graders. Copies of any of these bulletins will be forwarded on request to anyone writing for them to the Galion Iron Works & Mfg. Co., Galion, Ohio, or to any of their distributors.

Guard Fence.—Announcement from the Page Steel & Wire Company at Bridgeport tells of the completion of a new book (known as No. 169), developed around the results secured from a series of tests to determine the relative holding strength and effectiveness of the chain link type of highway guard. Several separate and distinct tests were completed, they ranging from the suspended, swinging weight—the method approved by the Underwriters' Laboratories—to actual impact by automobiles, trucks and tractors. In the pendulum test the suspended weight was 650 pounds and was dropped in a free swinging arc from a height of 68 feet. Of more interest, however, were the series of automobile impact tests. In these tests Page Highway Guard was stretched, in accordance with standard erection specifications, about 10 feet from the lower end of a 400-foot runway. Heavy cars were started from the top, three cars being allowed to coast, a fourth car with engine open full. Speed of the cars varied from 22 to 38 miles an hour—and in every instance the automobiles were stopped without injury to the car, it is reported. The Page Highway Guard was easily and quickly repaired, according to the manufacturers. The findings of these and other tests are detailed in the new Page book. The book also contains much valuable information on methods of installing and repairing highway guard.

Industrial Notes

The Belle City Mfg. Co., of Racine, Wis., who have had a large demand for their crawlers for plowing and other agricultural uses, as well as for construction and road work, have just received a wire for several more carloads of this equipment for immediate delivery. They report that rapid strides are being made in many foreign fields in the use of modern equipment for agricultural and industrial uses.

The Indiana Truck Corporation, Marion, Indiana, reports that orders for Indiana Trucks entered during the month of September show an increase of 41 per cent over the orders received in September, 1926. Indiana third quarter sales this year show a 35 per cent increase over their third quarter business of last year. This is on top of similar gains made during the first half of this year over last year.

The Bucyrus-Erie Company, on Jan. 1, took over the Bucyrus Company and the Erie Steam Shovel Company, under the plan announced in the recent consolidation, and the merger has become effective. The principal offices of the company will be at South Milwaukee, Wis., and Erie, Pa., with manufacturing plants at South Milwaukee, Erie and Evansville, Ind. There will be one consolidated domestic sales organization under Mr. A. C. Vicary, now vice-president of The Erie Steam Shovel Company, with offices and agencies in all the principal cities. Mr. D. P. Eells, now in charge of the foreign business of the Bucyrus Company, will be in charge of all foreign sales. W. S. Coleman is president of the new company. The Bucyrus Company has for 40 years been the leading manufacturer of powerful excavating machinery and the Erie Steam Shovel Company has dominated the field in the manufacture of small revolving shovels. The Bucyrus-Erie Company will offer a complete line of all sizes and types of shovels, draglines and dredges, including those driven by steam, electricity, gasoline and Diesel oil.

The Selden Truck Corporation, at Rochester, N. Y., announces their production is being doubled, starting immediately, to take care of the increasing demand for the new Roadmaster 6-cylinder 3-ton speed truck brought out early in the summer, and the improved Pacemaker just recently announced.

M. Russell Thayer has been appointed consulting engineer for the American Vitrolite Corporation. In his new capacity he will operate in all territories under the direction of the corporation, with his headquarters in Des Moines, Iowa. Mr. Thayer served as resident engineer and engineer of maintenance of way for the C. P. & St. L. Railroad and the Missouri Pacific lines, and as principal assistant engineer of construction for the Buffalo & Susquehanna Railroad until 1906. Upon leaving railroad work in the fall of 1906, Mr. Thayer joined the Illinois Highway Department, where he devoted his time to research on waterbound macadam and concrete highway bridges, and later instituted research on concrete highway construction. In 1913 he joined the service department of the Universal Portland Cement Co., remaining until 1915. In that year he joined the Portland Cement Association, working in conjunction with the Structural Materials Research Laboratories at Lewis Institute. In 1921 he joined the present organization as consulting engineer, operating in Illinois.

The Thew Shovel Company, Lorain, Ohio, has just announced the appointment of five new men to their rapidly increasing sales organization. This company has met with such favorable success in the field with their popular Lorain-75A and Lorain-60A shovels, cranes, draglines and back diggers that the following men have been secured to cope with the tremendous increase of sales. Their names are undoubtedly familiar to many in the contracting field. Mr. James S. Griffin, who has had valuable experience as a railroad contractor and in the sale of shovels and contractors' equipment in New Mexico, Colorado and Wyoming, will make his headquarters in Denver, Colorado, and cover the aforementioned states. Mr. E. L. Sparks will be in charge of sales in California. Mr. Sparks has had a wide experience in construction and sales work, for five years representing one of the large steam shovel companies in the New England states and later being connected with the Ohio Locomotive Crane Company. More recently he has been district manager in New York for the Williams Bucket Company. Mr. J. L. Trout has been assigned to the Pennsylvania, Ohio and West Virginia territory, having had five years' experience in the sale of power shovels and many years' experience as an operator. Mr. M. B. Garber has been appointed promotion engineer, as his many years' experience as sales manager with The Sanderson Cyclone Drill Company should prove valuable in solving problems of quarries and in the handling of crushed stone, sand and gravel, and other rock moving jobs. Mr. Garber is also active in the National Crushed Stone Association, having been chairman of the manufactureres' division last year. Mr. P. A. McMillen has been attached to the company's Chicago office as sales engineer.

The Indiana Truck Corporation, Marion, Indiana, manufacturers of Indiana Motor Trucks, announce the appointment of Mr. Herbert H. Swiss as manager of their export department, with this department now located at the factory. After a careful survey of export business and export conditions, and after contact with other companies doing a large volume of expert business, it was decided that this department should be handled direct from the factory. The foreign business in motor trucks is increasing rapidly and is capable of tremendous development during the next few years. The situation is perhaps comparable with the motor truck business in this country in 1913 and 1914. Mr. Swiss was selected for this important position because of his record, having had many years' experience in the export field in motor trucks, and has an acquaintance with automotive dealers and distributors throughout the world. He was export manager for several years for the Republic Motor Truck Company, and served in the same capacity for Ruggles Motor Truck Company for the past seven years.

The Goodall Rubber Company announces that after December 23, 1927, the New York branch will be located at their new building, 50 Murray St. Every modern convenience for the care, storage and shipping of rubber goods is being installed. Five telephone trunk lines: The key number, Barclay 9021, will insure prompt telephone service. The Goodall Rubber Company have specialized in the manufacture of quality rubber goods for thirty years. F. B. Williamson, Jr., the president of Goodall Rubber Company, started as a salesman in the New York district. Eighteen years ago he opened the New York branch, and since then he devoted his entire efforts to the proper construction of mechanical rubber goods.

The Superior Supply Company, 1836-60 South Kostner Avenue, Chicago, announce the appointment of Mr. S. J. (Sam) Cogan as assistant sales manager, to be in charge of field operations, effective January 1. He will be in close touch with all customers and available for any service request.

The Hercules Motors Corporation, of Canton, Ohio, announce an increased dividend payment of 33 1/3 per cent over 1926 and 100 per cent over 1925 on the capital stock, following the annual stockholders' meeting held in the company offices. The business of the company, which exhibited its products, internal combustion engines and power units in sizes ranging from 20 HP. to 120 HP. (both four and six cylinders) at the Good Roads Show at the Cleveland Auditorium, has grown steadily during the past several years and the company is now one of the outstanding producers of gasoline engines for all industrial requirements. A great number of the road construction and maintenance machines exhibited at this convention depend for their power upon Hercules. The former directors were re-elected. They are: H. H. Timken, president Timken Roller Bearing Co., Canton, Ohio; R. W. Gallagher, president East Ohio Gas Company, Cleveland, Ohio; E. A. Langenbach, Canton, Ohio; G. M. Mather, president Mather Spring Company, Toledo, Ohio; and Charles Balough, vice-president and general manager Hercules Motors Corporation. Officials of the company are looking for a continued increase during 1928. It is expected that several new models will be developed in the near future to meet the demands for constantly increased diversity of application.

The Hunter Machinery Company, with offices and warehouses in Detroit and Grand Rapids, Mich., have been appointed distributors for McKiernan-Terry pile hammers within the state of Michigan.

The Timken Roller Bearing Company has announced that an expenditure of $4,000,000 to be devoted to increasing the production facilities of the company has been authorized for the coming year. The greater part of this expansion program concerns the company's plant at Canton, where both the steel mill and the bearing manufacturing plant proper will be considerably enlarged. Among other features a new substation of greater kilowatt capacity will be built for supplying electric power for both the steel mill and the factory. Some idea of the magnitude of the expansion can be gained from the fact that the contracts for steel construction alone amount to $300,000 or more.

The Climax Engineering Company, of Clinton, Iowa, announces the appointment of the Equitable Equipment Company, 410 Camp Street, New Orleans, Louisiana, as a Climax sales and service representative for the territory of lower Louisiana and Mississippi. Equitable Equipment Company will maintan a stock of standard engine units and a complete assortment of repair parts for all models of Climax Trustworthy Engines. They offer the service of experienced service engineers to all Climax users.

The Selden Truck Corporation, of Rochester, N. Y., reports the receipt of an order for $50,000 worth of truck chasses and parts for immediate shipment to Helsingfors, Finland. At the Good Roads Convention held recently in Cleveland, the Selden Company exhibited two trucks of special design for road building work, both powered with 6-cylinder engines, and reports orders for $21,000 worth of these trucks were received at the show. In the New York National Automobile Show the Selden Company exhibited three trucks, ¾-ton Sedan DeLuxe, 2-ton Pacemaker and 3-ton Roadmaster, and reports orders for $20,000 worth of trucks were closed at this show.